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Charles de Bartolomé

Charles A.M. de Bartolomé

James Alm

James R. Alm

Jeffrey S. Zax

Jeffrey S. Zax

Randall P. Walsh

Terra McKinnish

Terra G. McKinnish

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Incidence of Development Impact Fees: Theory and Evidence

by

Phillip Drew Prosseda

B.S. United States Air Force Academy (1980)

M.P.P. John F. Kennedy School of Government, Harvard University (1988)

M.A. University of Colorado at Boulder (1996)

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Incidence of Development Impact Fees: Theory and Evidence

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This dissertation investigates the incidence of development impact fees from both a theoretical and empirical perspective. A model of two communities with existing immobile residents and open land for new residents is developed. New residents may choose to live in either community and do so to maximize utility. The Pareto efficient and competitive outcomes are characterized and conditions for an efficient outcome under competition are established. The properties of the model are then developed under a competitive system where new infrastructure is financed by a property tax on all residents. Model parameters such as the level of infrastructure, the level of amenity, the total number of new residents in the system, and income are varied and the effect on utility is analyzed. One community then chooses various levels of an impact fee as a substitute for property tax finance and the welfare effects of this change in finance mechanism are analyzed. Finally, both communities match impact fees and the welfare effects of this interaction are analyzed. It is found that the dominant welfare maximizing strategy for existing residents of any community is switch from property tax finance for new infrastructure to complete impact fee finance. An empirical investigation of the incidence of impact fees using a large data set from northern El Paso County is analyzed in a property tax capitalization framework. Various econometric models are employed to test the hypothesis of positive impact fee incidence. The empirical models generally support previous research indicating positive incidence.

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Chapter 1

Introduction

With the advent of tax and expenditure limitations, state and local governments have been searching for new sources of revenue to maintain or expand public services. The need for new sources of revenue has been particularly acute in localities that have experienced rapid growth. Many fast growing communities have enacted development impact fees to finance the new infrastructure necessary to accommodate growth. At first glance, impact fees seem to be an ideal way to alleviate congestion externalities caused by new residents. Traditional methods of financing new infrastructure rely on property taxes and make existing as well as new residents pay for the infrastructure associated with growth. Traditional thinking holds that property tax financing used to maintain a constant level of service from infrastructure is inefficient compared with impact fees because new residents impose a fiscal externality on existing residents and do not internalize the full cost of their locational decision.

The above argument seems to have substantial academic merit. Indeed, some economists implicitly model development impact fees as pigouvian taxes on congestion externalities.[1] While a simple pigouvian tax does raise the issue of housing affordability (depending on its incidence), the tradeoff may be justified based

[1] See Singell and Lillydahl, 1990. The authors model the development impact fee as an increase in building costs. However, if the externality is exactly correlated to the supply of new housing, the fee can be considered a pigouvian tax.

on efficiency grounds. When the tax restores proper locational incentives efficiency is enhanced.

This view, however, may be too narrow in scope because it does not analyze the impact fee in a system of communities nor does it consider how traditional property tax financing is affected with the addition of another revenue source. When only one community imposes an impact fee and other communities do not, residents may attempt to escape the fee by locating in non fee communities. This may have unintended price effects on both the fee levying and non-fee levying communities. Furthermore, if impact fees signal a community's willingness to prevent tax increases due to unanticipated growth or to maintain the quality of congestible infrastructure, the fee may be viewed as an amenity and induce demand side effects that have not been adequately studied. These demand side effects may cause housing prices to rise if they outweigh the effect of the tax on supply.

1.1 Review of the Primary Literature on Impact Fee Incidence

Watkins (1999) develops a single community incidence model of impact fees in which the fee is considered a tax on undeveloped land and is paid by the developer. He then investigates the degree of "back passing" to undeveloped land and the degree of "on passing" to developed land. His model uses linear demand and supply equations to develop an expression for the incidence of the fee. Watkins determines that the incidence of the fee not only depends on the elasticity of supply of raw land and the elasticity of demand for developed land "...but also in a complex way on a variety of other factors..." (Watkins 1999, p. 423). Watkins' main conclusion as it applies to this research is that the developer always absorbs at least half of the fee and

that only the remainder of the fee is subject to "back passing" or "on passing". This implies that impact fees should never increase housing prices by more than fifty percent of the fee.

Yinger (1998) develops a more complete model of impact fee incidence by implicitly incorporating multiple communities and mobile residents with an equal utility constraint. He also allows for the property tax capitalization of infrastructure into house values. Although he discusses the fee in relation to a balanced budget he does not formally model the balanced budget constraint nor does he allow the number of new residents in his community to change in response to the fee. Using this model, Yinger concludes that impact fees will not be fully passed on to buyers of new housing and also concludes that existing resident-landowners will be insulated from the cost of new infrastructure as well as receive a capital gain. However, he does qualify his conclusion by stating that "...fees may raise the price of land if they replace uncertainty about what infrastructure will be provided or about the possibility that development will occur with a known package of infrastructure and fees—and with development" (Yinger 1998, p. 34). He further states that:

> What is needed is an analysis of imperfectly mobile households, of a mix of mobile and immobile households, or of a metropolitan area that contains only a few communities, none of which is in the literature. (Yinger 1998, p. 31)

The best known empirical studies of the incidence of development are a study conducted of Loveland Colorado (Singell and Lillydahl 1990) and one done on Dunedin, Florida (Delaney and Smith 1989). Singell and Lillydahl's piece is by far the most cited empirical study on the incidence of impact fees. Their paper starts out with a partial equilibrium framework designed to show how impact fees will affect

market prices. It treats impact fees as a tax on suppliers that shifts the supply curve of new housing increasing the market price of both new and existing housing. Their empirical model employs a price index to gauge the anticipation of the impact fee. This index is then used to determine the most likely time period in which impact fees had an effect.

Regressions on old and new houses using a dummy variable for the period in which the impact fee had an anticipated effect indicate that the impact fee increased home prices by over three times the amount of the impact fee. If these results are taken at face value, their study indicates that impact fees have a significant and positive effect on prices. However, the over shifting of the fee is puzzling. Their partial equilibrium model indicates that the price increase should never exceed the level of the impact fee. Several explanations for over shifting, from carrying costs to a complete re-evaluation by builders of the total cost of the impact fee system, are offered. Singell and Lillydahl's most intriguing explanation forms a partial foundation for this research. It is hypothesized that demand may increase because "owners of existing housing perceive that they will no longer have the property tax burden associated with continued growth and infrastructure costs..." (Singell and Lillydahl 1990, p. 84.). Singell and Lillydahl study impact fees in isolation from surrounding communities and surprisingly do not include a continuous impact fee variable. They also do not consider the property tax in their empirical estimation.

Delaney and Smith (1989) investigate the effect of impact fees on existing housing prices and propose the same explanation as Singell and Lillydahl. They make the assumption that the primary method of financing infrastructure in the

absence of impact fees is the property tax. A switch to impact fee financing will shift the financing burden from all houses in a community to new housing. This eliminates the property tax burden of growth from existing housing.

Delaney and Smith's formulation of the problem does not explicitly test this hypothesis. The property tax is not modeled nor is it considered in the empirical estimation. In fact, several other hypotheses are offered as possible reasons why an impact fee would raise the price of existing housing. Their study creates a price index for a city that imposed impact fees and compares this index to an estimated index for the same city without impact fees. As expected, they find a significant increase in the prices of existing homes when the fee is imposed versus the estimation without the fee. The method does not allow for the interaction of communities which impose fees nor does it contain a continuous impact fee variable. Like Singell and Lillydahl, Delaney and Smith do not explicitly consider property tax capitalization in their empirical work.

1.2 Direction of the Study

Chapter 2 presents a model of two communities which can finance infrastructure for new residents with a property tax, an impact fee, or some combination of both. Existing residents are immobile and new residents can choose between communities to maximize utility. This model explicitly formulates community budget constraints and considers property tax capitalization. It is shown that efficiency is attained when both communities finance infrastructure with an impact fee and the property tax is set to zero. The model's properties are then

simulated under a three conditions. First, a complete property tax regime in both communities is established and the effect of exogenous parameter shifts illustrated. Second, only one community is assumed to use impact fee financing and it chooses a range of financing options from complete property tax to complete impact fee finance. This model illustrates that when only one community chooses impact fee finance, its land price may increase or decrease depending on the level of the fee. The community which does not employ the impact fee always experiences an increase in price. Finally, both communities match their impact fees. It is shown that both communities have a strong incentive to set the impact fee equal to the full cost of infrastructure and to avoid property tax finance altogether.

Chapter 3 develops an empirical model to test the possibility of negative impact fee incidence in a system of communities which use various combinations of property tax and impact fee finance. It explicitly incorporates the property tax into its estimation. The chapter uses data from a system of communities in northern El Paso County, Colorado and contains specific information on the level of impact fees over time in these communities. The results indicate that impact fees may cause housing prices to increase or decrease when neighboring communities are included and the absolute magnitude of the change may exceed one. Chapter 4 uses a price index methodology to test for the incidence of impact fees in the entire system of communities. This estimation does not allow for individual community interaction and finds that when impact fees are unevenly imposed throughout the system of communities the general result is a rise in the price of homes. The magnitude of this increase may exceed that of the impact fee.

Chapter 2

Theoretical Analysis of Impact Fees from the Planner and Competitive Perspectives

2.1 Introduction

This chapter considers a static model of two communities that provide congestible infrastructure to its residents. The purpose of the model is to determine the efficiency of a property tax versus an impact fee when financing infrastructure and to analyze the comparative statics of the two financing schemes.

The initial model is constructed from the perspective of an unbiased planner and the model is solved for the conditions which lead to a Pareto-efficient outcome. A model of a competitive economy is then developed. It is shown that a Pareto-efficient outcome in a competitive economy is achieved when both communities finance the public good with an impact fee levied on new residents and the property tax is set to zero.

The next section of the chapter analyzes the competitive model when only the property tax is used to finance the public good. Several exogenous variables in community 1 are individually varied and the comparative statics of the model under a property tax regime are established. The last section of the chapter analyzes two variants of impact fee financing in the competitive model. In the first case only one community switches from property tax to impact fee financing. A continuum of financing options, ranging from all property tax finance to all impact fee finance in one community, is presented and the comparative statics of this range is analyzed. In

the second case the comparative statics of the competitive model are analyzed when both communities match impact fees and tax rates.

2.2 The Planner's Problem: Characterizing a Pareto-efficient Allocation

This section develops the planner's problem in order to establish and analyze the conditions for a Pareto-efficient solution. The planner maximizes the utility of new residents in a community by allocating new residents between two communities, choosing a level of consumption for all residents, and allocating land to new residents. This occurs without causing deterioration in the quality of the infrastructure. The setup and assumptions of the model are listed below.

2.2.1 Setup and Assumptions of the Planner's Problem

There are two communities with existing residents. These residents are type 1s and the number of type 1s in each community is designated by $\overline{n_i^1}$. The i subscript denotes the community. Existing residents in each community are immobile. There is a given amount of new residents, type 2s, which must be allocated to empty land in each community. Type 2s are designated by, n_i^2. The subscript i, again denotes the community.

At the end of the allocation, all land is occupied. Existing residents consume a fixed and predetermined amount of land, $\overline{a_i^1}$ at the start and end of the allocation. The amount of land consumed by existing residents is equal within a community but may vary between communities. New residents consume an amount of land, a_i^2, that depends on the initial amount of empty land in each community and the final

distribution new residents between communities. The amount of land consumed by new residents is equal within a community but may vary between communities.

There is an exogenously predetermined level of infrastructure, Z_i, in each community prior to the allocation of new residents to communities. The planner need only provide infrastructure to new residents. Infrastructure is congestible and new entrants must be supplied with the same per capita amount of infrastructure as existing residents or the quality of infrastructure provided to all residents deteriorates. Each new resident must therefore be allocated the per capita amount of infrastructure that is present at the beginning of the allocation, $\overline{z}_i$, where $\overline{z}_i = \frac{Z_i}{\overline{n}_i^{1}}$ and Z_i is the total amount of infrastructure in community i before new residents enter the community. The cost of providing infrastructure to a new resident is the community's current per capita cost of infrastructure prior to the allocation of new residents. Infrastructure provision experiences constant returns to scale.

Individuals inelastically supply one unit of undifferentiated labor. Production of one unit of the numeraire good or one unit of infrastructure requires one unit of labor. Assuming that individuals are paid their marginal product, then the wage rate, $\overline{W}$, is equal to the value of one unit of x or one unit of z.

Utility of a type k individual in community i is a function of a numeraire good, x_i^k, land, a_i^k, and the level of a community amenity, g_i. $U_i^k = (x_i^k, a_i^k, g_i)$. Utility is not considered a function of infrastructure to simplify the model and get to the main issue of the efficiency of infrastructure finance.

Table 2.1 summarizes the variables in the planner's problem.

Table 2.1: Variables in the Planner's Problem

Variable	Description
x_1^1	Numeraire Good Allocated to Existing Residents in Community 1
x_1^2	Numeraire Good Allocated to New Residents in Community 1
x_2^1	Numeraire Good Allocated to Existing Residents in Community 2
x_2^2	Numeraire Good Allocated to New Residents in Community 1
a_1^1	Land Allocated to Existing Residents in Community 1
a_1^2	Land Allocated to New Residents in Community 1
a_2^1	Land Allocated to Existing Residents in Community 2
a_2^2	Land Allocated to New Residents in Community 2
n_1^2	Number of New Residents Allocated to Community 1
n_2^2	Number of New Residents Allocated to Community 2
g_1	Amenity Level in Community 1
g_2	Amenity Level in Community 2

2.2.2 Constraints in the Planner's Problem

The planner faces the following constraints. Utility of existing residents in community 1 and 2 is preset prior to the allocation of new residents. The preset utility of existing residents may differ between communities. All existing residents, regardless of community, are immobile. Existing residents also receive a predetermined and fixed amount of land and amenity levels of communities are preset by the planner prior to the allocation of new residents between communities. The marginal utility of the numeraire good, land, and the amenity is positive and decreasing. The utility function of existing residents takes the following form,

$U_i^1\left(x_i^1, \overline{a_i^1}, \overline{g_i}\right) = \overline{U_i^1}$. This implies that the amount of numeraire consumed by existing residents is determined by the preset level of utility, land, and amenity.

New residents must have the same utility across communities to prevent migration.

(1P) $$U_1^2\left(x_1^2, a_1^2, \overline{g_1}\right) = U_2^2\left(x_2^2, a_2^2, \overline{g_2}\right).$$

The value of consumption must equal the value of production. $\overline{W}$ is an identical wage earned by each worker and R is the potential transfer to landlords.

(2P) $$\overline{n_1^1} x_1^1 + \overline{n_2^1} x_2^1 + n_1^2 x_1^2 + n_2^2 x_2^2 + n_1^2 \overline{z_1} + n_2^2 \overline{z_2} = \left(\overline{n_1^1} + \overline{n_2^1} + n_1^2 + n_2^2\right)\overline{W} + R$$

All land is occupied in community 1 by existing or new residents.

(3P) $$\overline{A_1} = \overline{n_1^1 a_1^1} + n_1^2 a_1^2.$$

All land is occupied in community 2 by existing or new residents.

(4P) $$\overline{A_2} = \overline{n_2^1 a_2^1} + n_2^2 a_2^2.$$

New residents must be allocated across the two communities.

(5P) $$n_1^2 + n_2^2 = \overline{N^2}.$$

2.2.3 *Lagrangian*

The planner's problem is to maximize the utility of new residents in community 1 subject to the above constraints. x_1^1, x_2^1, $\overline{a_1^1}$, $\overline{a_2^1}$, $\overline{g_1}$, and $\overline{g_2}$ are suppressed where appropriate for notational convenience.

$$L = U_1^2(x_1^2, a_1^2) + \beta\{U_1^2(x_1^2, a_1^2) - U_2^2(x_2^2, a_2^2)\}$$
$$+\phi\{\overline{n_1^1} x_1^1 + \overline{n_2^1} x_2^1 + n_1^2 x_1^2 + n_2^2 x_2^2 + n_1^2 \overline{z_1} + n_2^2 \overline{z_2} - (\overline{n_1^1} + \overline{n_2^1} + n_1^2 + n_2^2)\overline{W} - R\}$$
$$+\alpha\{\overline{n_1^1 a_1^1} + n_1^2 a_1^2 - \overline{A_1}\} + \pi\{\overline{n_2^1 a_2^1} + n_2^2 a_2^2 - \overline{A_2}\} + \nabla\{n_1^2 + n_2^2 - N^2\}$$

2.2.4 *First Order Conditions (FOCs)*

The following six first order conditions result from the planner's problem.

1. $\dfrac{\partial L}{\partial x_1^2} = \dfrac{\partial U_1^2}{\partial x_1^2} + \beta \dfrac{\partial U_1^2}{\partial x_1^2} + \phi n_1^2 = 0$

2. $\dfrac{\partial L}{\partial x_2^2} = -\beta \dfrac{\partial U_2^2}{\partial x_2^2} + \phi n_2^2 = 0$

3. $\dfrac{\partial L}{\partial a_1^2} = \dfrac{\partial U_1^2}{\partial a_1^2} + \beta \dfrac{\partial U_1^2}{\partial a_1^2} + \alpha n_1^2 = 0$

4. $\dfrac{\partial L}{\partial a_2^2} = -\beta \dfrac{\partial U_2^2}{\partial a_2^2} + \pi n_2^2 = 0$

5. $\dfrac{\partial L}{\partial n_1^2} = \phi(x_1^2 + \overline{z_1} - \overline{W}) + \alpha a_1^2 + \nabla = 0$

6. $\dfrac{\partial L}{\partial n_2^2} = \phi(x_2^2 + \overline{z_2} - \overline{W}) + \pi a_2^2 + \nabla = 0$

2.2.5 Efficiency Conditions

The following efficiency conditions arise.

1. $$\frac{\dfrac{\partial U_1^2}{\partial a_1^2}}{\dfrac{\partial U_1^2}{\partial x_1^2}} = \frac{\alpha}{\phi}$$ is derived from first order conditions 1 and 3.

2. $$\frac{\dfrac{\partial U_2^2}{\partial a_2^2}}{\dfrac{\partial U_2^2}{\partial x_2^2}} = \frac{\pi}{\phi}$$ is derived from FOCs 2 and 4.

3. $x_1^2 - x_2^2 + \overline{z_1} - \overline{z_2} = \frac{\pi}{\phi} a_2^2 - \frac{\alpha}{\phi} a_1^2$ is derived from FOCs 5 and 6.

Efficiency condition 1 can be interpreted to imply that the marginal rate of substitution of the numeraire and land for new residents in community 1 is equal to the rate at which income would be traded for land by new residents in that community. Intuitively, the lagrange multiplier α is the rate that the objective function changes with respect to a change in the amount of free land in community 1 and the lagrange multiplier ϕ is the rate that the objective function changes when income is changed. Efficiency condition 2 has a similar interpretation. It implies that the marginal rate of substitution of the numeraire and land for new residents in community 2 is equal to the rate at which income would be traded for new land in that community. In this condition the lagrange multiplier π is the rate that the objective function changes with respect to a change in the amount of free land in community 2.

Efficiency condition 3 is a bit more challenging to interpret. Rearranging terms and using efficiency conditions 1 and 2 to eliminate the lagrange multipliers yields:

$$(6P)\qquad (x_1^2+\overline{z_1})-(x_2^2+\overline{z_2})=\frac{\dfrac{\partial U_2^2}{\partial a_2^2}}{\dfrac{\partial U_2^2}{\partial x_2^2}}a_2^2-\frac{\dfrac{\partial U_1^2}{\partial a_1^2}}{\dfrac{\partial U_1^2}{\partial x_1^2}}a_1^2$$

The left hand side of equation (6P) represents the cost associated with moving an individual from community 2 to community 1 and the right hand side of equation (6P) represents the resource gain associated with that move. Both sides are measured in terms of the numeraire.[2] For example, if a new resident is moved from community 2 to community 1, land is freed up in community 2 and can be reallocated to the remaining new residents in community 2. Therefore a_2^2 increases. If all else is held constant, the utility of new residents in community 2 increases because there is more land per new resident. Similarly, when a new resident is transferred to community 1 from community 2, each new resident in community 1 must give up some land to make room for their new neighbor. Therefore a_1^2 decreases. All else constant, the utility of new residents in community 1 declines. In order to maintain the equal utility constraint, some of the numeraire good must be reallocated from new residents in community 2 to new residents in community 1.[3]

[2]Recall that a unit of the numeraire trades one for one with a unit of infrastructure.

[3] Because the per capita amount of infrastructure is fixed, the only way to balance the utility of new residents in different communities is to transfer the numeraire from new residents in one community to new residents in the other community.

2.3 Characterizing a Competitive Allocation

In the competitive problem, existing and new residents maximize utility subject to a budget constraint. Existing residents are immobile and only choose the level of consumption of the numeraire. New residents choose both the numeraire and the amount of land. Communities maintain a balanced budget and pay for infrastructure by imposing a property tax on all land of the community, imposing an impact fee on new residents only, or some combination of both. Each community has an exogenous level of amenity. An equal utility constraint for new residents ensures that that these residents are satisfied with their choice and migration between communities does not occur. The equal utility constraint indirectly factors into community choice and therefore the level of amenity consumed by new residents.

Exogenous variables in this problem include: income per resident; level of infrastructure per resident in each community; the impact fee in each community; total land area in each community; the amount of land occupied by existing residents in each community; number of existing residents in each community; the total number of new residents in the system; and the level of amenity in each community. The endogenous variables include: The amount of numeraire consumed by each type of resident in each community; the amount of land consumed by new residents in each community; the distribution of new residents between communities; the price of land in each community; and the tax rate in each community. Table 2.2 below lists all of the variables in the competitive problem.

Table 2.2: Variables in the Competitive Problem

Variable	Description	Type
$\overline{W}$	Income per Resident	Exogenous
$\overline{z_1}$	Cost of Infrastructure per Resident in Community 1	Exogenous
$\overline{z_2}$	Cost of Infrastructure per Resident in Community 2	Exogenous
$\overline{I_1}$	Impact Fee in Community 1	Exogenous
$\overline{I_2}$	Impact Fee in Community 2	Exogenous
$\overline{A_1}$	Total Land Area in Community 1	Exogenous
$\overline{A_2}$	Total Land Area in Community 2	Exogenous
$\overline{a_1^1}$	Land per Existing Resident in Community 1	Exogenous
$\overline{a_2^1}$	Land per Existing Resident in Community 2	Exogenous
$\overline{n_1^1}$	Number of Existing Residents in Community 1	Exogenous
$\overline{n_2^1}$	Number of Existing Residents in Community 2	Exogenous
$\overline{N^2}$	Total Number of New Residents in the System	Exogenous
$\overline{g_1}$	Amenity in Community 1	Exogenous
$\overline{g_2}$	Amenity in Community 2	Exogenous
x_1^1	Numeraire Consumed by Existing Residents in Community 1	Endogenous
x_1^2	Numeraire Consumed by New Residents in Community 1	Endogenous
x_2^1	Numeraire Consumed by Existing Residents in Community 2	Endogenous
x_2^2	Numeraire Consumed by New Residents in Community 2	Endogenous
a_1^2	Land Consumed by New Residents in Community 1	Endogenous
a_2^2	Land Consumed by New Residents in Community 2	Endogenous
n_1^2	Number of New Residents in Community 1	Endogenous
n_2^2	Number of New Residents in Community 2	Endogenous
P_1	Price of Land in Community 1	Endogenous
P_2	Price of Land in Community 2	Endogenous
t_1	Tax rate in Community 1	Endogenous
t_2	Tax rate in Community 2	Endogenous

The individual budget constraints for existing residents of each community and for new residents of each community are listed below. As mentioned, all residents within a community are charged the same tax rate to pay for new infrastructure. New residents of a community can also be charged an exogenous impact fee, $\overline{I}_i$, determined by the community. In this formulation d is the discount rate used to convert land price to a perpetual rental payment.

(1C) $$\overline{W} = x_1^1 + P_1(d + t_1)\overline{a_1^1}.$$

(2C) $$\overline{W} = x_2^1 + P_2(d + t_2)\overline{a_2^1}.$$

(3C) $$\overline{W} = x_1^2 + P_1(d + t_1)a_1^2 + \overline{I}_1.$$

(4C) $$\overline{W} = x_2^2 + P_2(d + t_2)a_2^2 + \overline{I}_2.$$

The first order conditions for the new residents' maximization problem follow.

(5C) $$\frac{\dfrac{\partial U_1^2}{\partial a_1^2}}{\dfrac{\partial U_1^2}{\partial x_1^2}} = P_1(d + t_1).$$

(6C) $$\frac{\dfrac{\partial U_2^2}{\partial a_2^2}}{\dfrac{\partial U_2^2}{\partial x_2^2}} = P_2(d + t_2).$$

Community 1 and 2 must achieve budget balance. Here $\overline{z}_i$ is the per capita amount of infrastructure that must be provided to each new resident to keep the quality of infrastructure constant.[4]

$$\overline{n_1^1} P_1 t_1 \overline{a_1^1} + n_1^2 P_1 t_1 a_1^2 + n_1^2 \overline{I_1} = n_1^2 \overline{z_1} . \tag{7C}$$

$$\overline{n_2^1} P_2 t_2 \overline{a_2^1} + n_2^2 P_2 t_2 a_2^2 + n_2^2 \overline{I_2} = n_2^2 \overline{z_2} . \tag{8C}$$

The price adjusts such that new residents achieve the same utility regardless of the community they choose and all land is occupied.

$$U_1^2\left(x_1^2, a_1^2, \overline{g_1}\right) = U_2^2\left(x_2^2, a_2^2, \overline{g_2}\right). \tag{9C}$$

All new residents must reside in one of the communities.

$$n_1^2 + n_2^2 = \overline{N^2} . \tag{10C}$$

All land is occupied.

$$\overline{A_1} = \overline{n_1^1 a_1^1} + n_1^2 a_1^2 \tag{11C}$$

$$\overline{A_2} = \overline{n_2^1 a_2^1} + n_2^2 a_2^2 \tag{12C}$$

2.4 Proof that the Competitive Problem Is Pareto-efficient

To show that the competitive equilibrium is Pareto-efficient when impact fees are used to completely finance the new infrastructure, set $t_1 = t_2 = 0$; $I_1 = z_1$; and $I_2 = z_2$ and show that the six equations of the planner's problem are satisfied in the competitive allocation. The competitive allocation can be written as:

[4] Recall that the infrastructure for existing residents has already been paid for.

$\left(\widetilde{x}_1^1, \widetilde{x}_2^1, \widetilde{x}_1^2, \widetilde{x}_2^2, \widetilde{a}_1^2, \widetilde{a}_2^2\right)$. All equations of the planner's problem are now evaluated at the competitive equilibrium.

Equation (1P) of the planner's problem is the equal utility constraint and is satisfied by equation (9C) of the competitive problem. Equation (2P) of the planner's problem states that the value of consumption must equal the value of production plus the potential transfer to landlords. To show that this equation is satisfied in the competitive problem, multiply the individual budget constraints (1C-4C) by the number of each type of individual (n_i^k) respectively and then sum the four budget constraints. The final step is to realize that the payment for land by the residents is equal to the rent received by landlords. Equations (3P) and (4P) are satisfied by equations (11C) and (12C) and equation (5P) of the planner's problem is satisfied by equation (10C) of the competitive problem.

Finally, to show that equation (6P) is satisfied, set the right hand side of the new residents' budget constraints in the competitive problem equal (equations 3C and 4C). This results in: $x_1^2 + P_1 d\, a_1^2 + \overline{z}_1 = x_2^2 + P_2 d\, a_2^2 + \overline{z}_2$ and rearranging terms yields: $(x_1^2 + \overline{z}_1) - (x_2^2 + \overline{z}_2) = P_2 d\, a_2^2 - P_1 d\, a_1^2$. From the competitive problem, equation (5C) shows $\dfrac{\partial U_1^2 / \partial a_1^2}{\partial U_1^2 / \partial x_1^2} = P_1 d$ and equation (6C) shows $\dfrac{\partial U_2^2 / \partial a_2^2}{\partial U_2^2 / \partial x_2^2} = P_2 d$.

Equation (6P) of the planner's problem is therefore satisfied by the equations of the competitive problem.

2.5 Analysis of the Model Under a Property Tax Regime

The main purpose of the comparative static analysis of the competitive model is to assess the effect of moving from a system of financing new infrastructure with a property tax to a system which relies on an impact fee. However, before this analysis is undertaken, general properties of the model under a property tax system are established to demonstrate the behavior of the system of communities when other exogenous variables are changed. This analysis is insightful when later studying the change from a system of property taxation to one in which infrastructure is financed with an impact fee.

Ideally an analytic solution to the model can be found and the derivatives easily signed. However, this was not possible given the complexity of the model. Inspection of the first derivatives of the general model reveal that they depend on the form of the utility function employed and levels of both the exogenous and endogenous variables. To circumvent this difficulty, a Cobb Douglas utility function was assumed and numerical simulations were then employed. The utility function has the following specific form: $g^{0.01} x^{0.85} a^{0.15}$. Some of the results of these simulations are therefore dependent on the Cobb Douglas assumption.

Once the specific form of the utility function was assumed, a selected exogenous variable was varied across its range and an equilibrium solution for the endogenous variables was computed for each level of the given exogenous variable. The comparative statics of each solution were also computed. The program used to compute the equilibrium solutions and comparative statics is found at Appendix A.

2.5.1 Initial Symmetry under the Property Tax Regime

Initially, both communities are assumed to be identical and operating under a property tax only. The area of each community is fixed at two square miles and half of each community is occupied by immobile existing residents. The number of existing residents in each community is equal and the land that is consumed per existing resident is equal. The number of new residents in the system is set equal to the total number of existing residents in the system. The initial symmetry of the problem aids in analysis of the properties of the model. Table 2.3 shows the initial values for all exogenous variables when complete symmetry is used.

Due to the total symmetry of the problem, simulating the model with these initial conditions leads to communities that are identical with respect to all the endogenous variables. That is, the rental price of land, amount of land consumed per resident, consumption of the numeraire, tax rates, and the distribution of new residents between communities are the same. The amount of land consumed by new and existing residents is equal within and across communities. Additionally, because the total number of new residents in the system is set equal to the total number of existing residents in the system, each community ends up with exactly the same number of residents and all residents regardless of type or community have the same level of utility. Table 2.4 displays the results for the endogenous variables for this simulation.

Table 2.3: Initial Values for Exogenous Variables

Variable	Description	Value
$\overline{W}$	Income per Resident	\$100,000
z_1	Cost of Infrastructure per Resident in Community 1	\$15,000
z_2	Cost of Infrastructure per Resident in Community 2	\$15,000
I_1	Impact Fee in Community 1	\$0
I_2	Impact Fee in Community 2	\$0
A_1	Total Land Area in Community 1	2560 acres
A_2	Total Land Area in Community 2	2560 acres
a_1^1	Land per Existing Resident in Community 1	0.25 acres
a_2^1	Land per Existing Resident in Community 2	0.25 acres
n_1^1	Number of Existing Residents in Community 1	5120
n_2^1	Number of Existing Residents in Community 2	5120
N^2	Total Number of New Residents in the System	10240
a	Amenity Parameter in the Utility Function	0.01
g_1	Amenity in Community 1	\$15,000
g_2	Amenity in Community 2	\$15,000
b	Consumption Parameter in the Utility Function	0.85
$1-b$	Land Parameter in the Utility Function	0.15
d	Discount Rate	0.03

Table 2.4: Values for Endogenous Variables Using Symmetric Initial Conditions

Variable	Description	Value
x_1^1	Numeraire Consumed by Existing Residents in Community 1	\$85,000
x_1^2	Numeraire Consumed by New Residents in Community 1	\$85,000
x_2^1	Numeraire Consumed by Existing Residents in Community 2	\$85,000
x_2^2	Numeraire Consumed by New Residents in Community 2	\$85,000
a_1^2	Land Consumed by New Residents in Community 1	0.25 acres
a_2^2	Land Consumed by New Residents in Community 2	0.25 acres
n_1^2	Number of New Residents in Community 1	5120
n_2^2	Number of New Residents in Community 2	5120
P_1	Price of Land in Community 1	\$1,000,000
P_2	Price of Land in Community 2	\$1,000,000
$P_1 d$	Rental Price of Land in Community 1	\$30,000
$P_2 d$	Rental Price of Land in Community 2	\$30,000
t_1	Tax Rate in Community 1	0.03
t_2	Tax Rate in Community 2	0.03
$P_1(d+t_1)$	After Tax Rental Price of Land in Community 1	\$60,000
$P_2(d+t_2)$	After Tax Rental Price of Land in Community 2	\$60,000

An expression for the tax rate can be derived from the Cobb Douglas form and the initial symmetric conditions. The tax rate for communities 1 and 2 are given by the following equations.

(1) $$t_1 = \frac{d(z_1 - I_1)}{(2b-1)I_1 + (1-b)2W - z_1}$$

(2) $$t_2 = \frac{d(z_2 - I_2)}{(2b-1)I_2 + (1-b)2W - z_2}$$

These equations are derived by using the community budget constraints and the demand functions for land derived from the Cobb Douglas utility function. Recall from equation (7C) of the competitive problem that community 1's budget constraint is given by:

$$\text{(7C)} \qquad \overline{n_1^1} P_1 t_1 \overline{a_1^1} + n_1^2 P_1 t_1 a_1^2 + n_1^2 \overline{I}_1 = n_1^2 \overline{z}_1 .$$

Rearranging yields:

$$\text{(7C')} \qquad \overline{n_1^1} P_1 t_1 \overline{a_1^1} + n_1^2 P_1 t_1 a_1^2 = n_1^2 \left(\overline{z}_1 - \overline{I}_1 \right)$$

Using the fact that half of community 1's land is occupied by existing residents and the other half is occupied by new residents, it is known that new residents must pay one half of the property tax necessary to finance new infrastructure. Equation (7C)' can therefore be rewritten as:

$$\text{(7C'')} \qquad n_1^2 P_1 t_1 a_1^2 = \frac{n_1^2 \left(\overline{z}_1 - \overline{I}_1 \right)}{2}$$

Eliminating n_1^2 yields:

$$\text{(7C''')} \qquad P_1 t_1 a_1^2 = \frac{\left(\overline{z}_1 - \overline{I}_1 \right)}{2}$$

The demand for land by new residents in community 1, $a_1^2 = \dfrac{(1-b))(W - \overline{I}_1)}{P_1(t_1 + d)}$, can be derived by maximizing the specific form of the Cobb Douglas utility function subject to the budget constraint described in equation (3C) of the competitive problem and substituted into (7C)'''. This eliminates price and now the tax rate in community 1 can be solved in terms of the exogenous variables in the problem. The result is

equation (1) above. Equation (2) is found by a similar method. In this section the impact fee is assumed to be zero so equation (1) and (2) reduce to:

(1')
$$t_1 = \frac{d\,z_1}{(1-b)2W - z_1}$$

(2')
$$t_2 = \frac{d\,z_2}{(1-b)2W - z_2}$$

Equations (1)' and (2)' are useful when analyzing the properties of the model under a property tax regime. Because the tax rate of a given community is only a function of the per capita level of infrastructure, income, the discount rate, and land's share, the tax rate will be constant for many of the situations below.

Equations for the price of land and the number of new residents per community are more complex and can be found in Appendix B.

2.5.2 Effect on Utility and Endogenous Variables When the Level of Infrastructure Is Varied in Community 1 under a Property Tax Regime

This simulation holds all exogenous variables at their initial values and varies only the per capita amount of infrastructure in community 1. The major result of this simulation relative to the initial case reveals that as the level of infrastructure in community 1 is varied from \$0 to \$15,000 the rental price of land in community 1 drops and the tax rate in community 1 rises. These values converge to those in community 2 as the level of infrastructure approaches that of community 2. No other endogenous variables are affected. The rental price of land in community 2 and the after tax price of land in both communities remains constant. Figures 2.1 and 2.2 display these results.

Figure 2.1: Rental Price of Land vs. Level of Infrastructure in Community 1
(level of infrastructure in community 2 = $15,000)

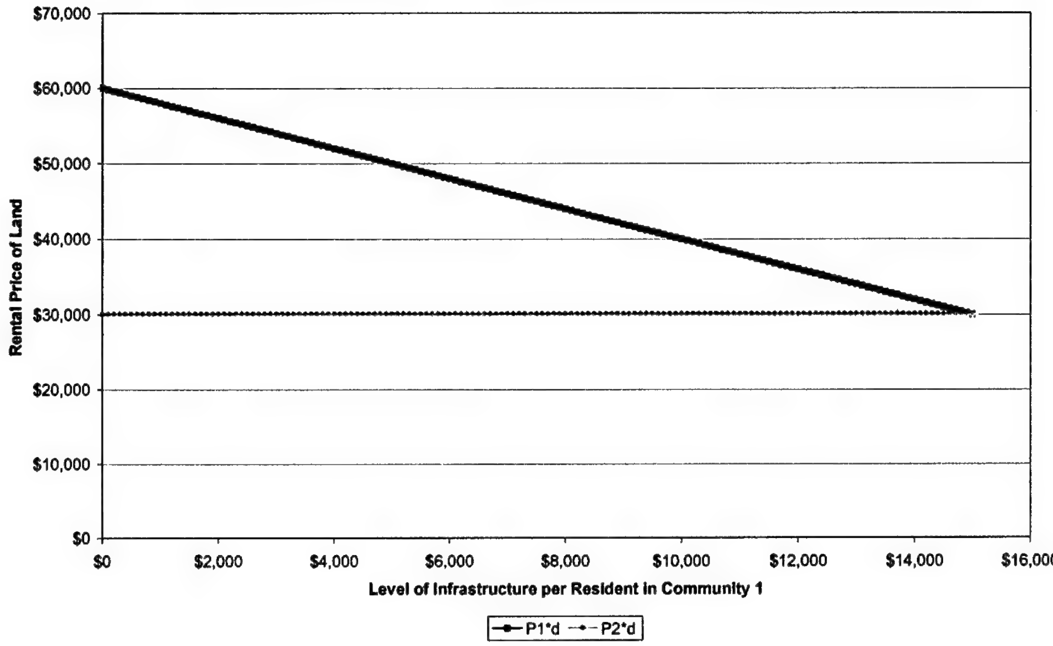
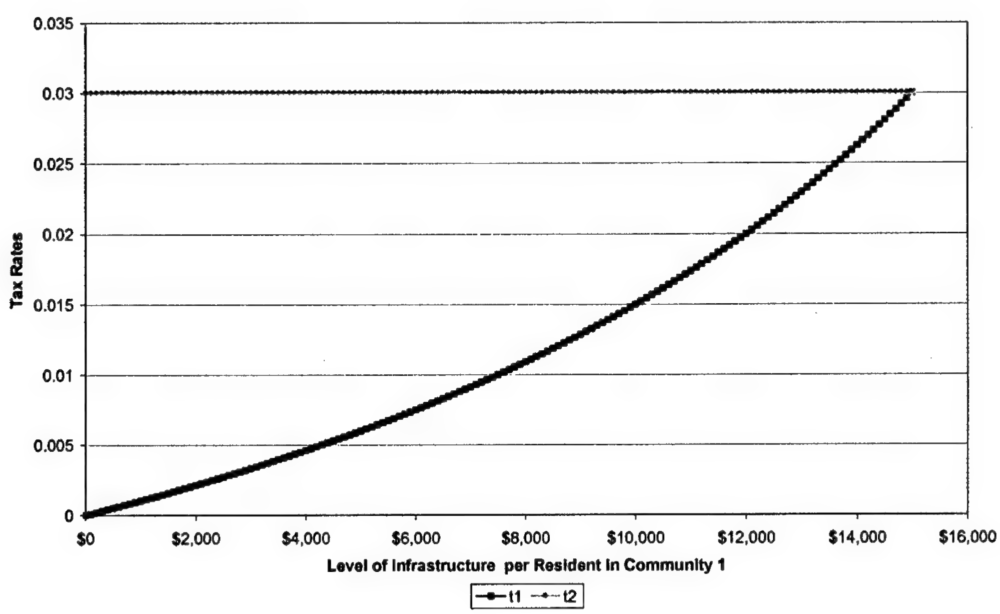
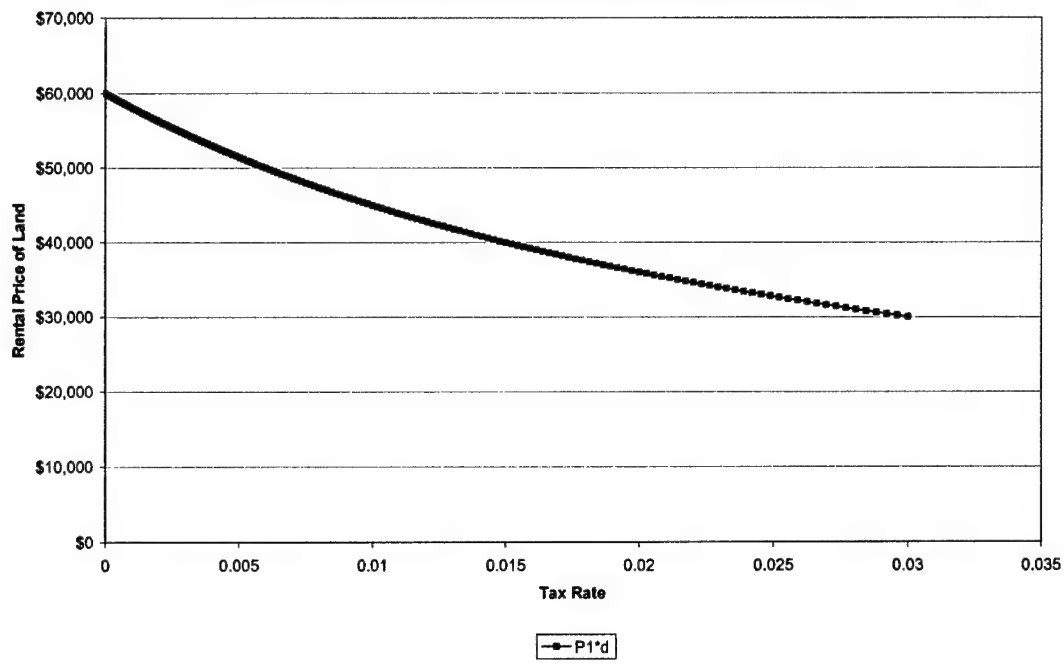


Figure 2.2: Tax Rates vs. Level of Infrastructure in Community 1
(level of infrastructue in community 2 = $15,000)



The level of utility attained by all residents remains the same and is equal throughout the range of infrastructure for community 1. This occurs because as the tax rate in community 1 is increased to finance the increased infrastructure, the rental price of land drops, keeping the rental payment plus the tax payment constant in this community. More precisely, the after tax rental price of land, $P_1(d+t_1)$, is constant. Consumption of the numeraire and land therefore remains constant. This is the standard capitalization result and in this model 100 percent of the infrastructure cost is capitalized into land prices. Figure 2.3 plots the rental price of land versus tax rates and demonstrates the capitalization effect.

Figure 2.3:
Rental Price of Land in Community 1 vs. Tax Rate in Community 1



2.5.3 Effect on Utility and Endogenous Variables When the Level of Amenity Is Varied in Community 1 Under a Property Tax Regime

This simulation varies the level of amenity in community 1 from \$0 to \$15,000. All other exogenous variables remain at their initial values in Table 2.3.

The biggest influence of increasing the amenity in community 1 in the competitive model is the redistribution of new residents from community 2 to community 1. A higher amenity level in community 1 leads to a higher level of utility for all new residents. Since available land is constant in each community, land consumption per new resident drops in community 1 and increases in community 2. However, even when the drop in land consumption by new residents in community 1 is taken into account, the net effect on the utility of these residents in is positive. New residents in community 2 benefit primarily from an increase in land consumption as population density of new development decreases. Consumption of the numeraire good for new residents does not change. The net result is an increase in utility for all new residents as the amenity level in community 1 is increased. This result applies more generally. If the level of amenity is increased for any community, the utility of all new residents regardless of community increases.

The increase in amenity for community 1 also increases the utility of all existing residents regardless of community. For existing residents in community 1 there is a direct effect from the increased amenity. This direct effect is damped by an indirect effect on consumption due to an increase in the rental price of land and an increase in the tax payment (not tax rate) which reduces income available for consumption. However, the increase in utility due to the amenity still swamps the indirect effect on the utility of existing residents in community 1. If the assumption is made that rent is paid to absentee landlords, then landlords in community 1 incur a capital gain on their land due to the increase in rental price. The existing residents in community 2 benefit from a lower rental price of land and a reduction in the total tax

payment (not tax rate). This frees income to be spent on more of the numeraire good. If one assumes that existing residents pay rent to absentee landlords, then landlords suffer a capital loss in community 2. An interesting result is that the increase in land price in community 1 is exactly offset by the decrease in land price in community 2. The net effect on landlords as a group is therefore zero. The increase in the amenity level in any community in this model is welfare enhancing for all residents under the assumption that residents rent from absentee landlords. While the utility of the owners of land in community 2 decreases due to the lower rental price of land, the total effect on residents and landlords as measured by equivalent variation is positive. Figures 2.4 through 2.8 show the major results of the simulation.

Figure 2.4: # New Residents per Community vs. Amenity Level in Community 1 (amenity level in community 2 = $15,000)

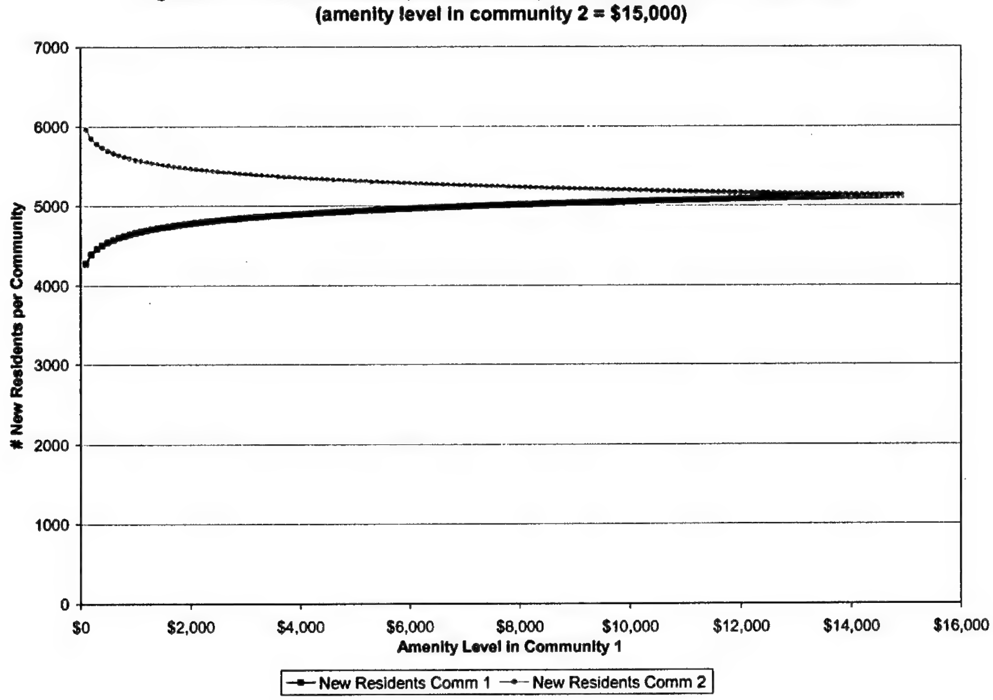


Figure 2.5: Rental Price of Land vs. Amentiy In Community 1 (amenity level in in community 2 = $15,000)

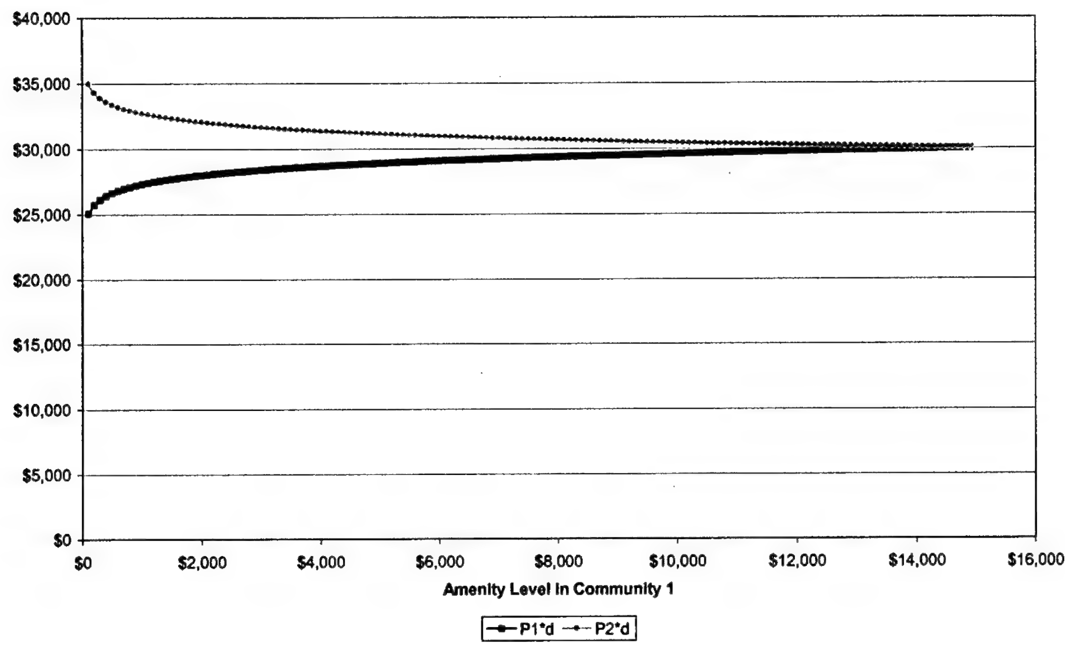


Figure 2.6: Equivalent Variation per Resident vs. Amenity Level in Community 1 (amenity level in community 2 = $15,000)

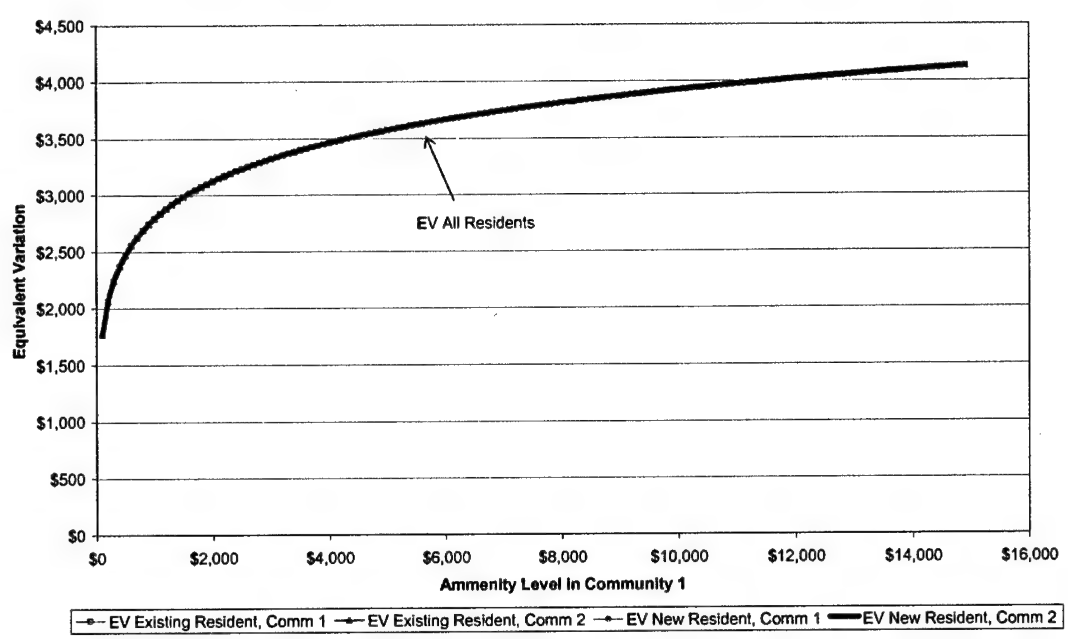


Figure 2.7: Land per New Resident vs. Amenity Level in Community 1
(amenity level in community 2 = $15,000)

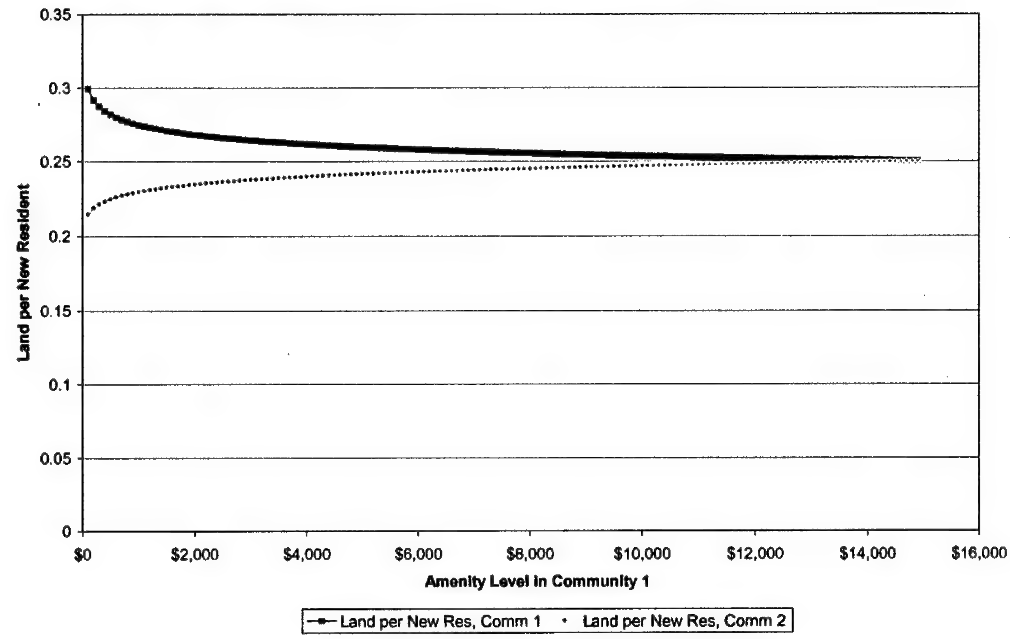
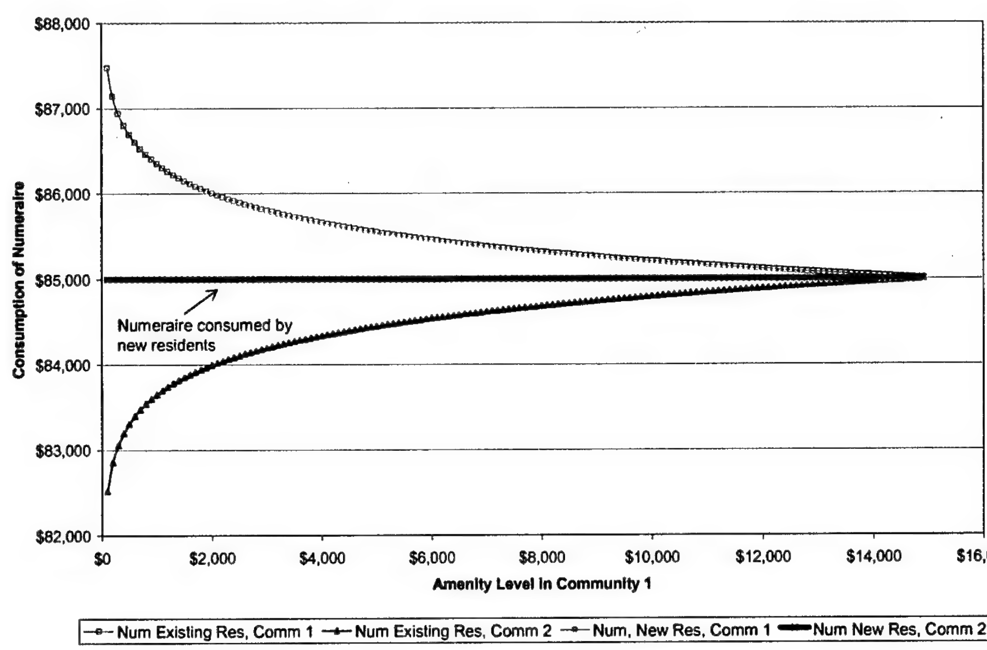


Figure 2.8: Consumption of Numeriare vs. Amenity in Community 1
(amenity level in community 2 = $15,000)



2.5.4 *Effect on Utility and Endogenous Variables When the Total Number of New Residents in the System Is Varied Under a Property Tax Regime*

This simulation varies the total number of new residents in the system of communities from 2 to 20,400. As the total number of new residents is increased, the new residents are distributed equally between communities and their land area decreases. This has a symmetric effect on both communities. The net result of an increase in new residents is an increase in the rental price of land, an increase in total infrastructure in each community to accommodate the new residents, and an increase in total tax revenue necessary to fund the increase in infrastructure. From equations (1)' and (2)' it can bee seen that tax rates remain constant because per capita infrastructure and income remains constant. The increased infrastructure cost is therefore financed by the increase in the rental price of land. An interesting feature of this simulation is that the individual tax payment made by an existing resident increases as the number of new residents increases but the individual tax payment of a new resident remains constant. This is because the rental price of land is increasing (with a constant tax rate) while the land area of an existing resident is fixed. The land area for a new resident, in contrast, is decreasing and this offsets the increase in rental price. To the extent that the model captures the crowding phenomenon, infrastructure provision, and tax system of the real world, it helps explain the clamor for impact fees by existing residents when there is a significant amount of growth. Figures 2.9 – 2.11 illustrate these results.

Figure 2.9: Rental Price of Land vs. Total # of New Residents (existing # of residents = 10240 evenly divided between communities)

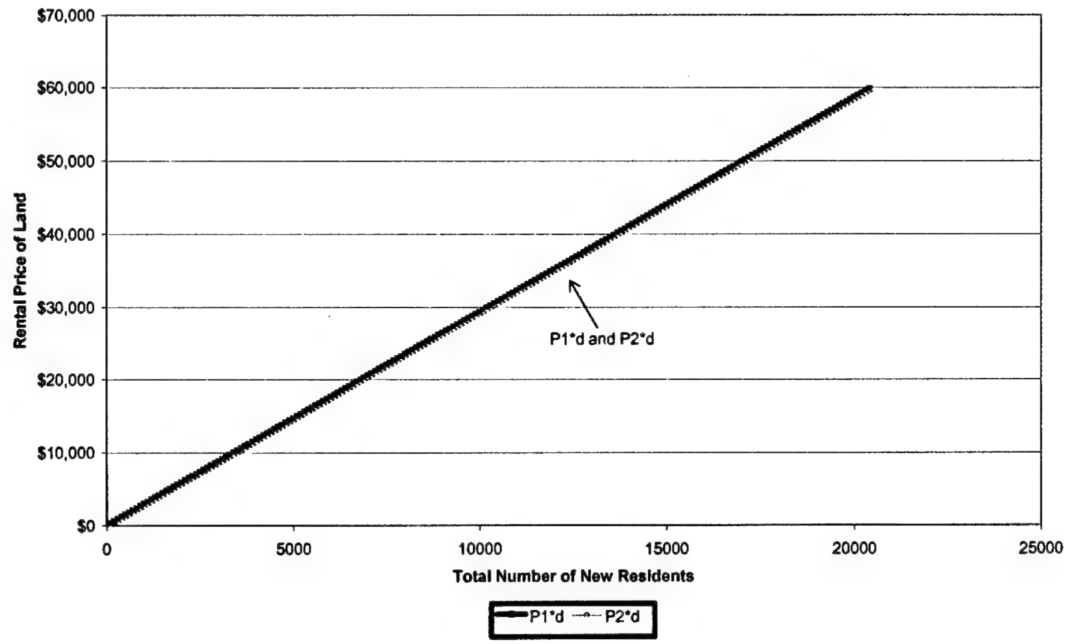


Figure 2.10: # of New Residents per Community vs. Total # of New Residents (existing # of residents = 10240 evenly divided between communities)

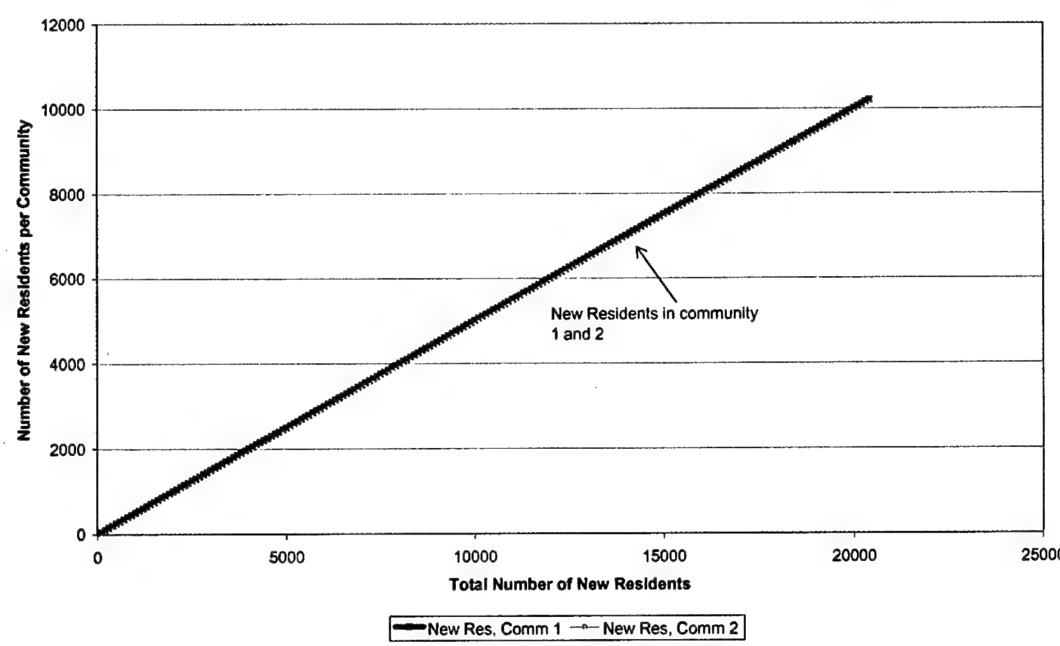
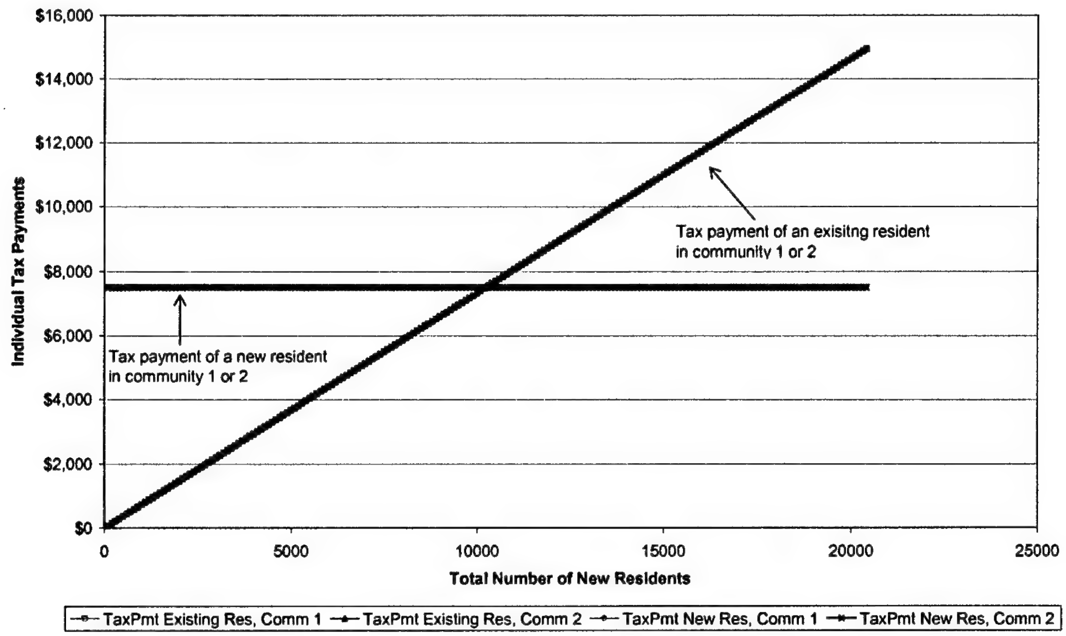


Figure 2.11: Individual Tax Payment vs. Total # of New Residents
(existing # of residents = 10240 evenly divided between communities)



As mentioned, consumption of land by new residents decreases due to the fixed area available in each community. However, the rental payment to land for a new resident remains the same for the same reason that the tax payment made by new residents is constant. This implies that the income available for consumption by a new resident remains constant and the only factor affecting a new resident's utility is the drop in land consumption. By way of comparison, an existing resident's tax payment, as well as her rental payment to land, both increase due to the fact that land is fixed for this individual. Existing residents therefore suffer a decrease in utility due to a drop in consumption. When equivalent variation is aggregated over the entire population including landlords, the net change in utility from an increase in new residents is negative.[5] Figures 2.12 - 2.15 illustrate the result of this simulation.

[5] All residents are weighted equally.

Figure 12.12: Land per New Resident vs. Total # of New Residents (existing # of residnets = 10240 evenly divided between communities)

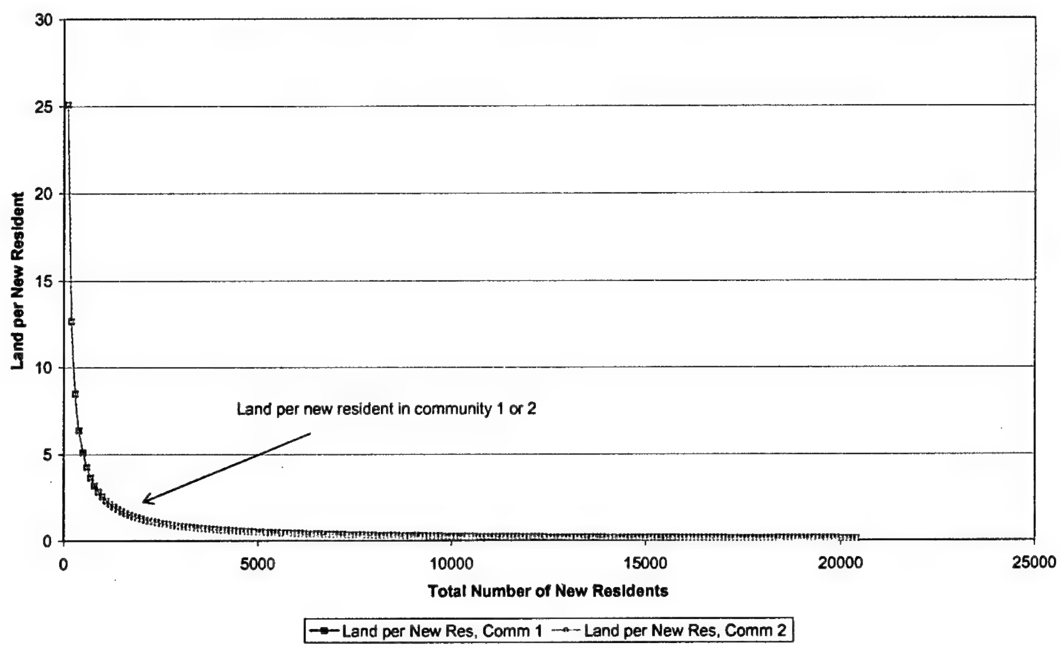


Figure 2.13: Consumption per Resident vs. Total # New Residents (existing number of residents = 10240 evenly divided between communities)

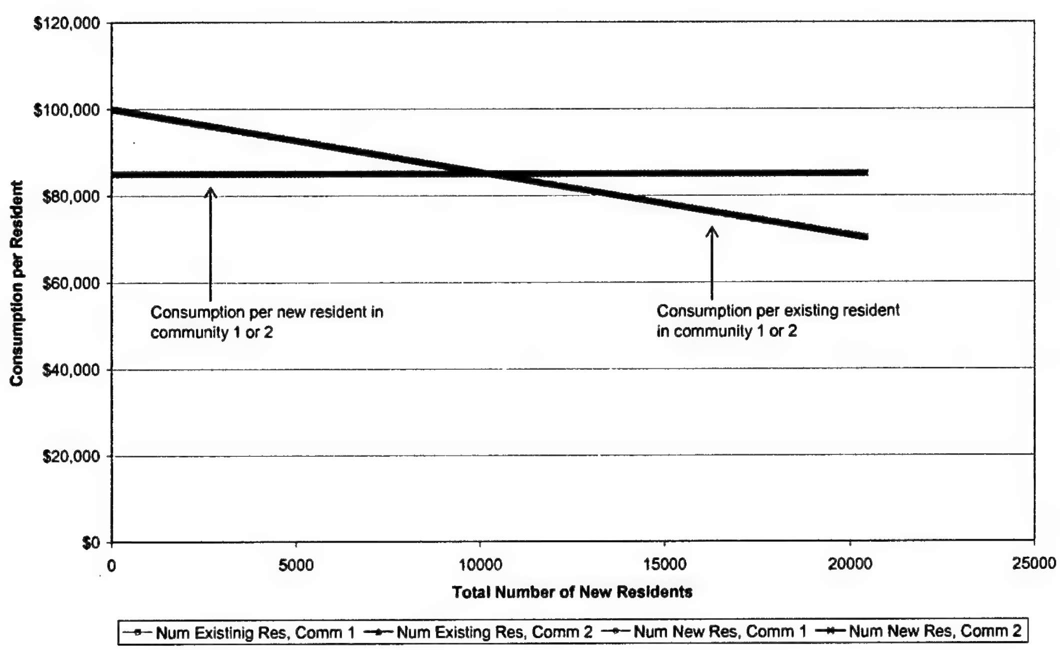


Figure 2.14: Equivalent Variation per Resident vs. Total # New Residents (existing # of residents = 10240 evenly divided between communities)

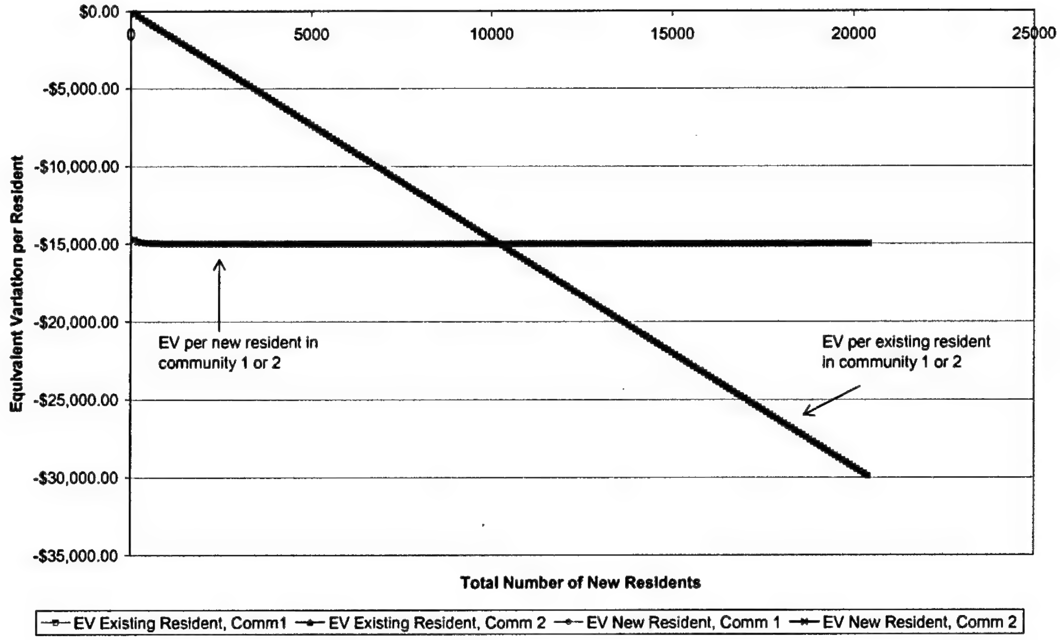
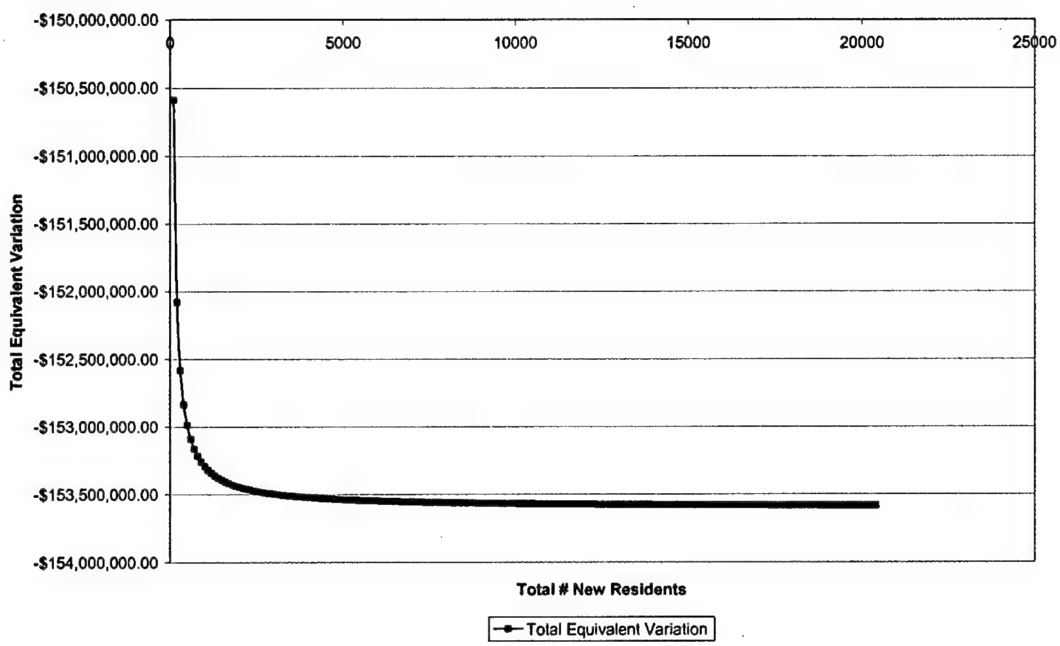


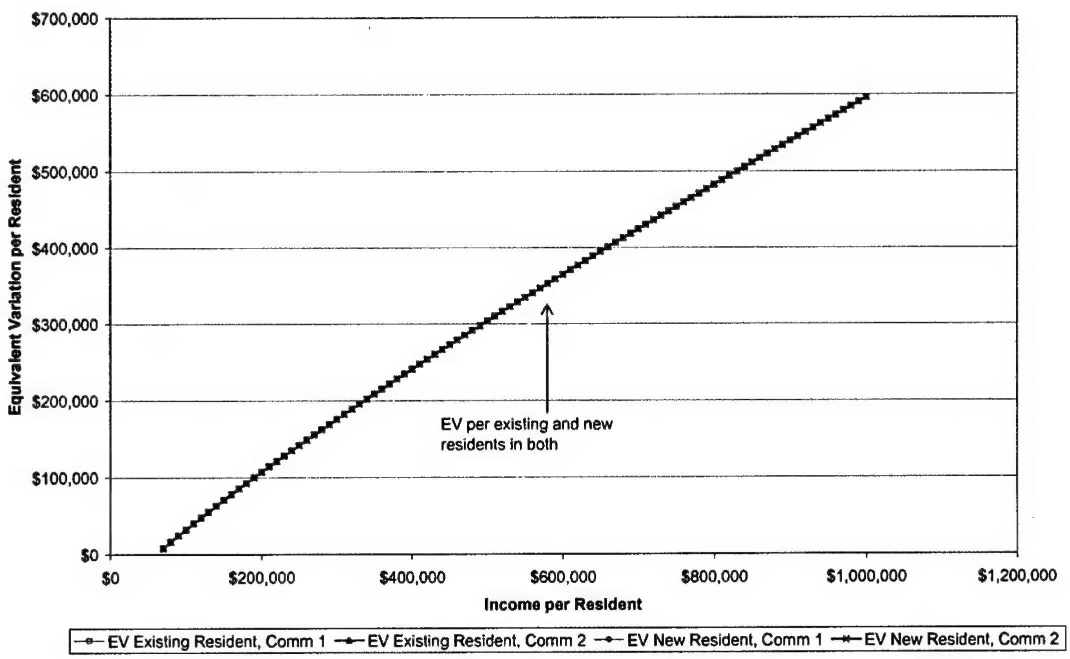
Figure 2.15: Total Equivalent Variation vs. Total # New Residents (existing # of residents = 10240 evenly divided between communities)



2.5.5 *Effect on Utility and Endogenous Variables When Income per Resident Is Varied Under a Property Tax Regime*

This simulation varies the income per resident from \$50,000 to \$1,000,000.[6] All residents receive the same income in this model. Increasing income increases utility by affording more consumption of the numeraire good. It also increases the rental price of land in both communities. Because the rental price of land increases and the total cost of infrastructure remains constant, the tax rate drops as income increases. The distribution of new residents between communities and the amount of land consumed is not affected. All endogenous variables that do change are affected in like manner. Figures 2.16 through 2.19 illustrate the results of this simulation.

Figure 2.16: Equivalent Variation per Resident vs. Income per Resident



[6] Given the initial conditions, individuals with incomes below \$50,000 cannot afford these communities. As can be seen from equations (1)' and (2)' incomes below \$50,000 produce negative tax rates. The price is also negative in this range.

Figure 2.17: Rental Price of Land vs. Income per Resident

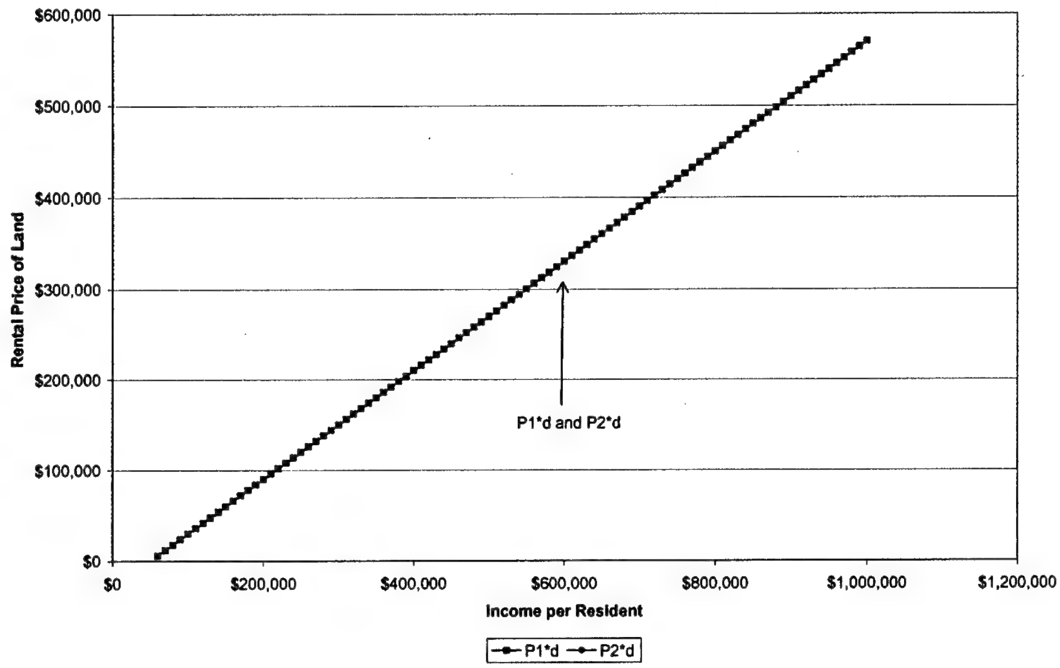


Figure 2.18: Tax Rate vs. Income per Resident

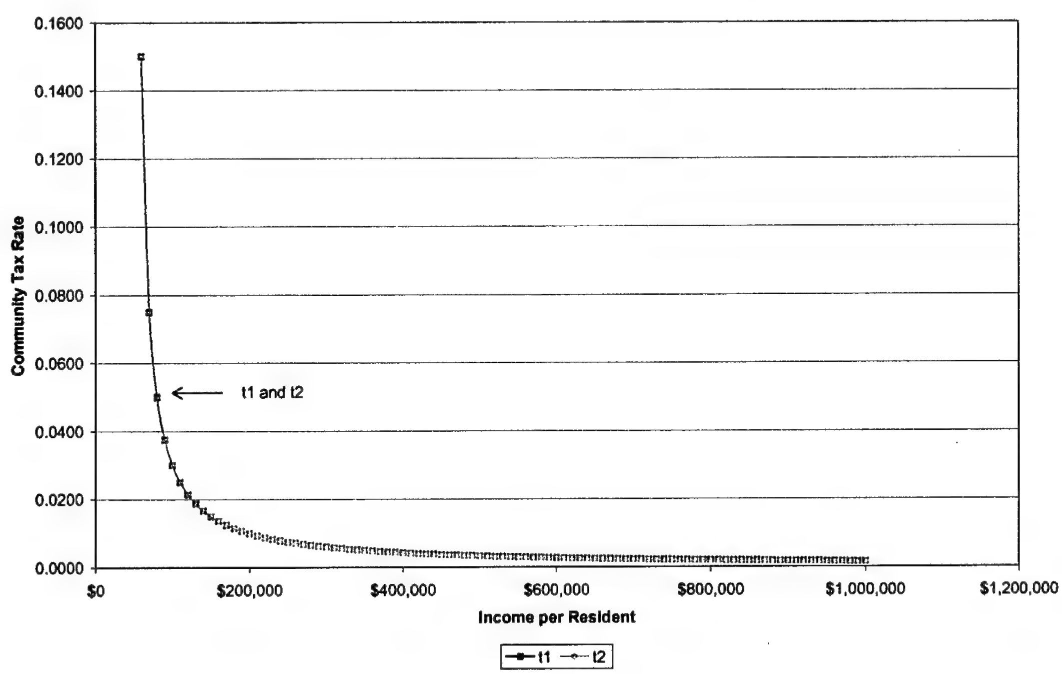
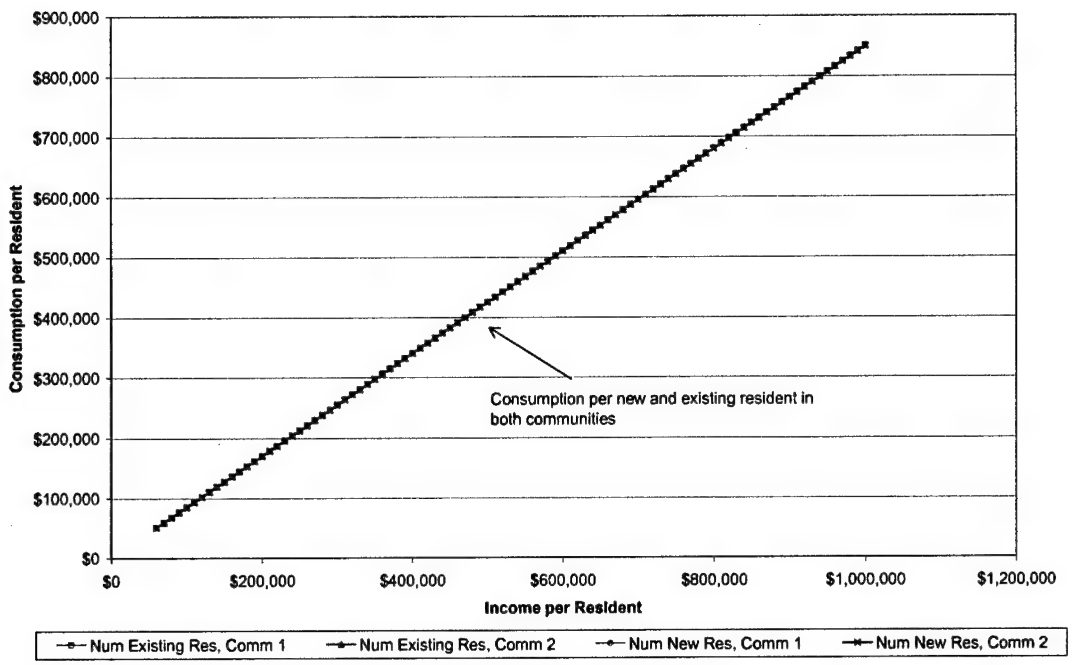


Figure 2.19: Consumption per Resident vs. Income per Resident



2.5.6 General Conclusions Under a Property Tax Regime

The results above generally hold regardless of the initial symmetry of the communities. Increasing infrastructure per resident in a given community results in a decrease in land price as the increased infrastructure cost is capitalized into land values. The decreased land price results in a lower rental payment but the savings are exactly offset by the necessity of an increased tax rate and a resulting increase in the tax payment. Land price in the community without an increase in infrastructure per new resident is unchanged. Landlords in the community that increases infrastructure per new resident, however, suffer a loss due to the decrease in the price of land. The net result of an increase in infrastructure per new resident in a given community is a constant level of utility for all residents in the system and no redistribution of new residents.

Increasing the amenity level in any community is welfare enhancing for all residents in the system. The community experiencing the increased amenity level experiences an increase in the rental price of land while the community with the constant amenity level experiences a drop in the rental price of land. New residents are redistributed to the community with the increased amenity.

An increase in the total number of new residents in the system reduces land consumption for new residents in proportion to the initial distribution of residents between communities. New residents are distributed between communities based on the initial amenity levels. An increase in the number of residents increases land price in both communities and is welfare reducing for all residents. New residents' utility declines due to lower land consumption and existing residents utility declines due to an increased tax burden and consequent drop in consumption of the numeraire good.

Finally, an increase in income is welfare enhancing for all residents. An increase in income does not change the distribution of new residents between communities. However it does increase the rental price of land and lower tax rates in both communities.

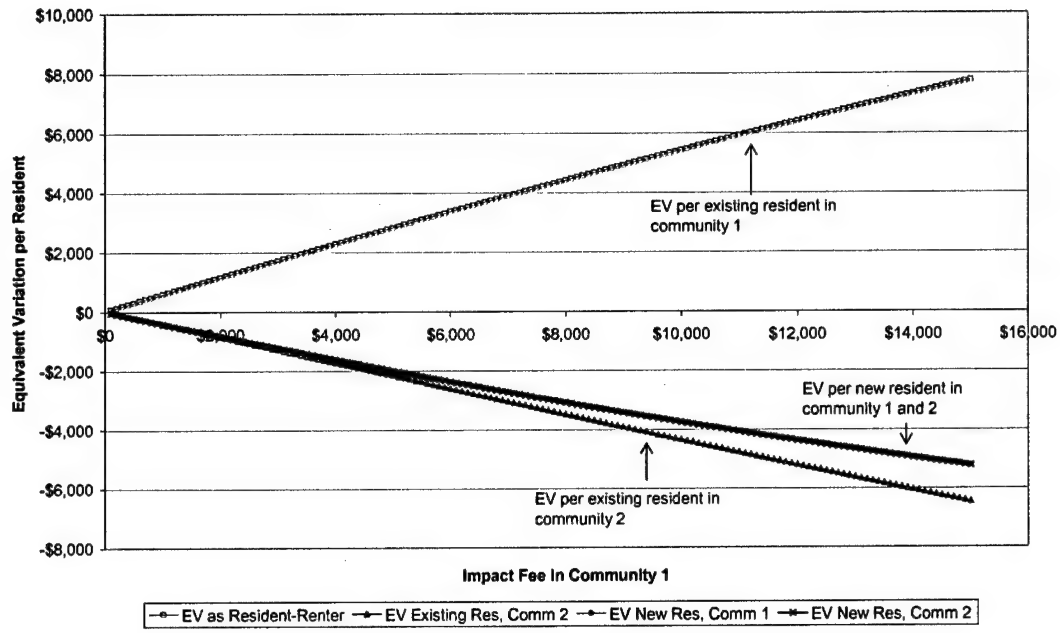
2.6 Analysis of the Model When Impact Fee Finance Is Introduced

This section introduces impact fee finance as a funding mechanism for new residents' infrastructure. The first set of simulations assumes that community 1 introduces fees in isolation and the second set analyzes the case of matching fees.

2.6.1 *Effect on Utility and Endogenous Variables When Community 1 Switches from a Property Tax Regime to an Impact Fee.*

In this simulation, the infrastructure finance of community 1 is steadily switched from complete property tax finance to complete impact fee finance. Community 2 continues to fund its infrastructure with a property tax. Landlords in community 1 experience an increase in the rental price of land at low levels of the impact fee. However, the rental price begins to drop at higher levels of the fee and eventually falls below the initial price at high levels of the fee. Landlords in community 2 experience a steady increase in the rental price of land (see figure 2.26). Impact fee financing is welfare enhancing for existing residents of community 1 at all levels of the impact fee. It is welfare reducing for all other residents of the system. Figure 2.20 illustrates the equivalent variation results for new and existing residents. Existing residents of community 2 fare the worst in this experiment as the rental payment for land and the increased tax payment (not tax rate) reduce income available for consumption of the numeraire good.

Figure 2.20: Equivalent Variation per Resident vs. Impact Fee in Community 1
(community 2 finances infrastructure with a property tax)



As the impact fee is increased in community 1, new residents in community 1 attempt to escape the fee and some relocate to community 2. An intuitive way to think about this is to consider the imposition of the impact fee as a reduction of income for any new resident that chooses community 1. This reduction in income lowers the utility of new residents in community 1. Because the utility of new residents in both communities is constrained to be equal, utility of new residents in community 2 must decrease. This occurs as the number of new residents in community 2 increases and the amount of land per new resident in community 2 decreases due to the fixed amount of land available. New residents in community 2 receive a lower level of utility solely because of the decrease in land consumption.

Price signals must adjust in the competitive model to reallocate land. As the distribution of new residents tips toward community 2, the after tax rental price of land in community 1, $P_1(t_1+d)$, must decrease and the after tax rental price of land in

community 2, $P_2(t_2+d)$, must increase. This corresponds with an increase in land consumption per new resident in community 1 and a decrease in land consumption per new resident in community 2. Figures 2.21 through 2.23 show these results.

Figure 2.21: Number of New Residents per Community vs. Impact Fee in Community 1

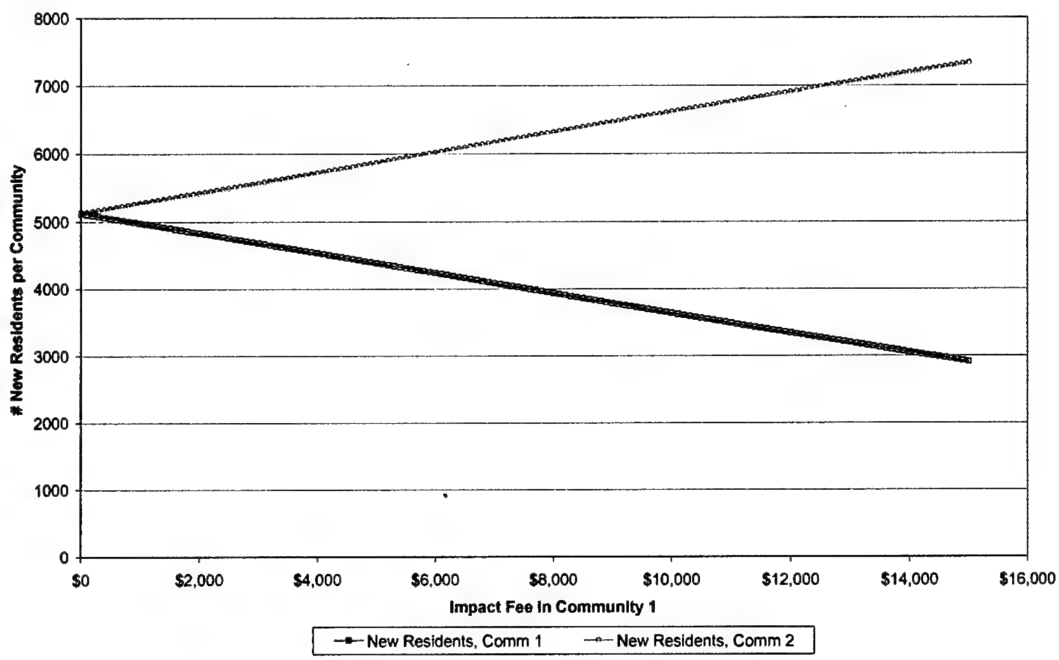


Figure 2.22: Land per New Resident vs. Impact Fee in Community 1

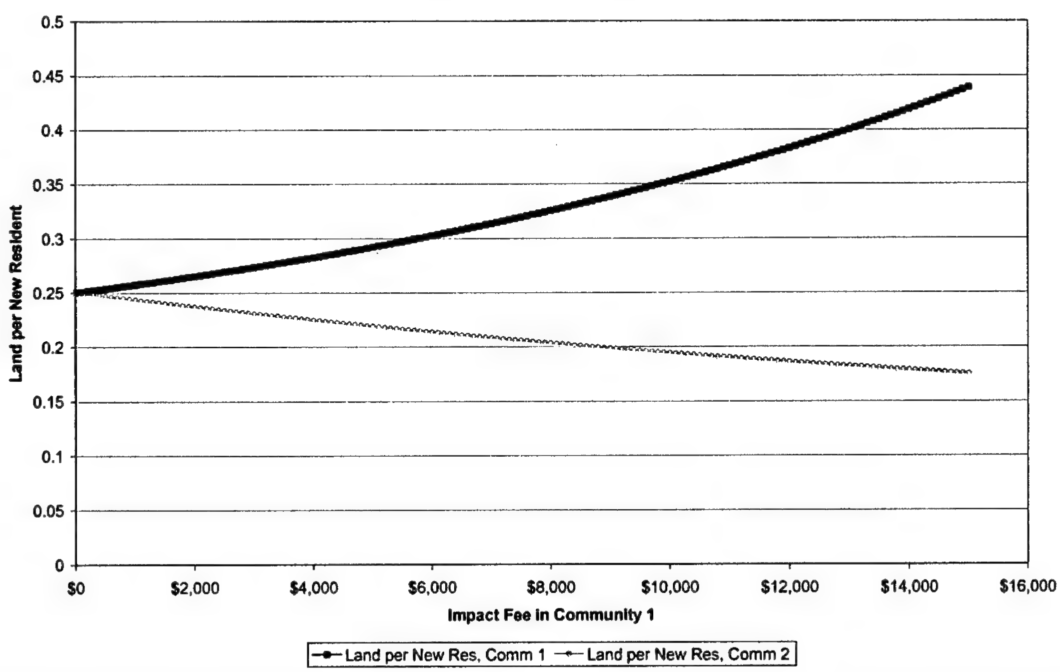
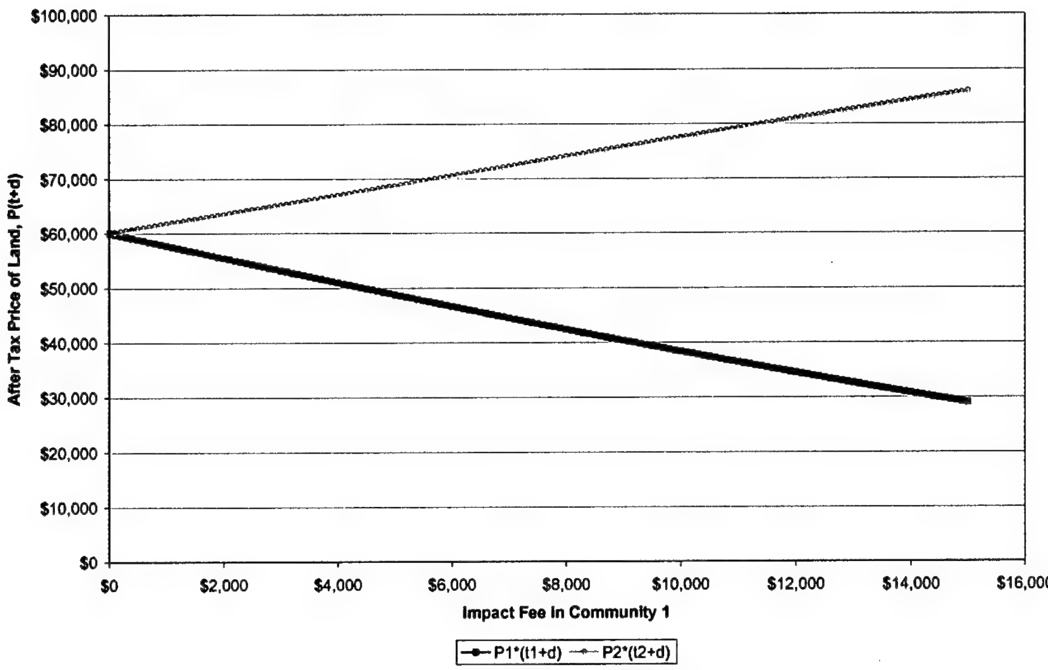


Figure 2.23: After Tax Rental Price of Land vs. Impact Fee in Community 1



The drop in new residents in community 1 means that the total infrastructure cost for this community and therefore the total revenue necessary to fund this infrastructure declines. Additionally, as the impact fee is increased, the component of total revenue derived from taxes decreases. Recall from the competitive problem that the budget balance condition must hold for community 1. Budget balance is given by:

(7C) $$n_1^1 P_1 t_1 a_1^1 + n_1^2 P_1 t_1 a_1^2 + n_1^2 I_1 = n_1^2 \bar{z}_1.$$

Rearranging this equation yields:

(7C') $$P_1 t_1 \left(n_1^1 a_1^1 + n_1^2 a_1^2\right) = n_1^2 \left(\bar{z}_1 - I_1\right)$$

The left hand side of this equation is property tax revenue. The right hand side of the equation is the amount of infrastructure in community 1 that must be financed by the property tax. Additionally, the expression in parenthesis on the left hand side of equation (7C') is the total land area of community 1 and it is constant. As the number

of new residents in community 1, n_1^2, declines and the tax revenue necessary to fund new infrastructure per resident, $\left(\overline{z}_1 - I_1\right)$, declines the expression P_1t_1 must decline. Intuitively, one expects that the tax rate should decrease because less tax revenue is necessary as the impact fee is increased. This turns out to be true. Equation (1), repeated below, expresses the tax rate in community 1 as a function of the exogenous variables of the model.

$$(1) \qquad t_1 = \frac{d\left(z_1 - I_1\right)}{(2b-1)I_1 + (1-b)2W - z_1}$$

The tax rate in community 1 depends only on the impact fee in community 1, the level of infrastructure per resident in community 1, income represented by *W*, the discount rate, represented by d, and the numeraire's share of utility, represented by b. If mild restrictions are placed on the numeraire's share and the impact fee such that b is greater than or equal to 0.5 and the impact fee is never greater than the cost of infrastructure, it can be shown that tax rates decline with an increase in the impact fee. In this simulation b is set equal to 0.85 and the impact fee is always less than or equal to infrastructure cost.

The expression for the tax rate for community 2 is symmetric to that of community 1. Equation (2), repeated below, expresses this tax rate as a function the exogenous variables of the model.

$$(2) \qquad t_2 = \frac{d\left(z_2 - I_2\right)}{(2b-1)I_2 + (1-b)2W - z_2}$$

Because the impact fee in community 2 is set to zero and does not vary in this simulation, the tax rate in community 2 is constant. Figure 2.24 illustrates the total property tax revenue that must be raised in each community as the impact fee in community 1 is increased and Figure 2.25 illustrates the prevailing tax rates.

Figure 2.24: Total Tax Revenue vs. Impact Fee In Community 1

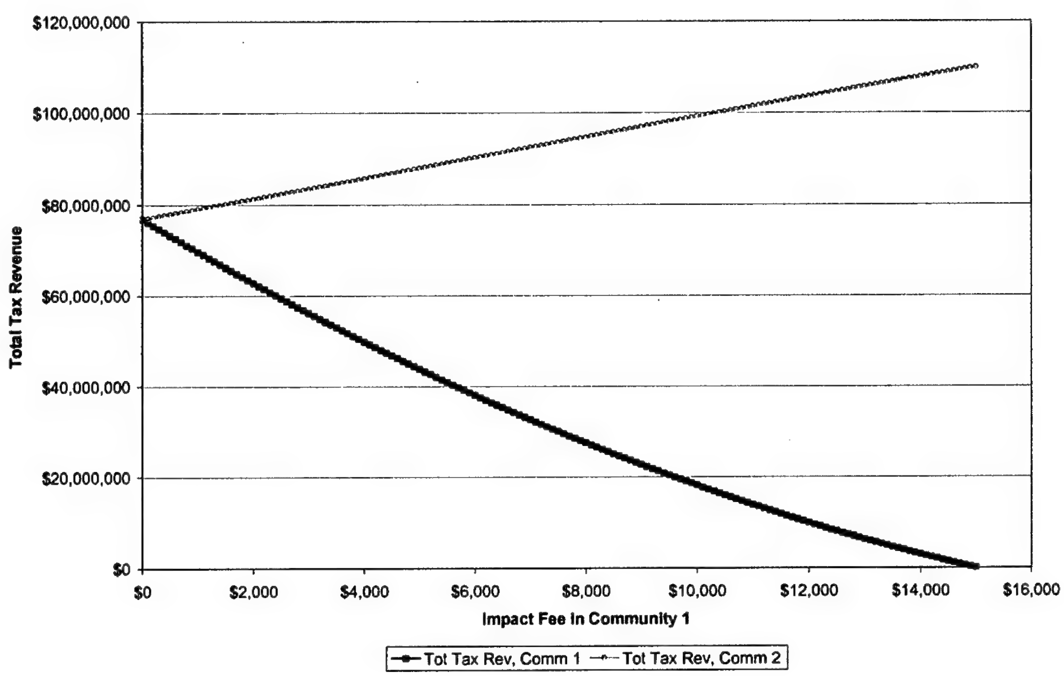
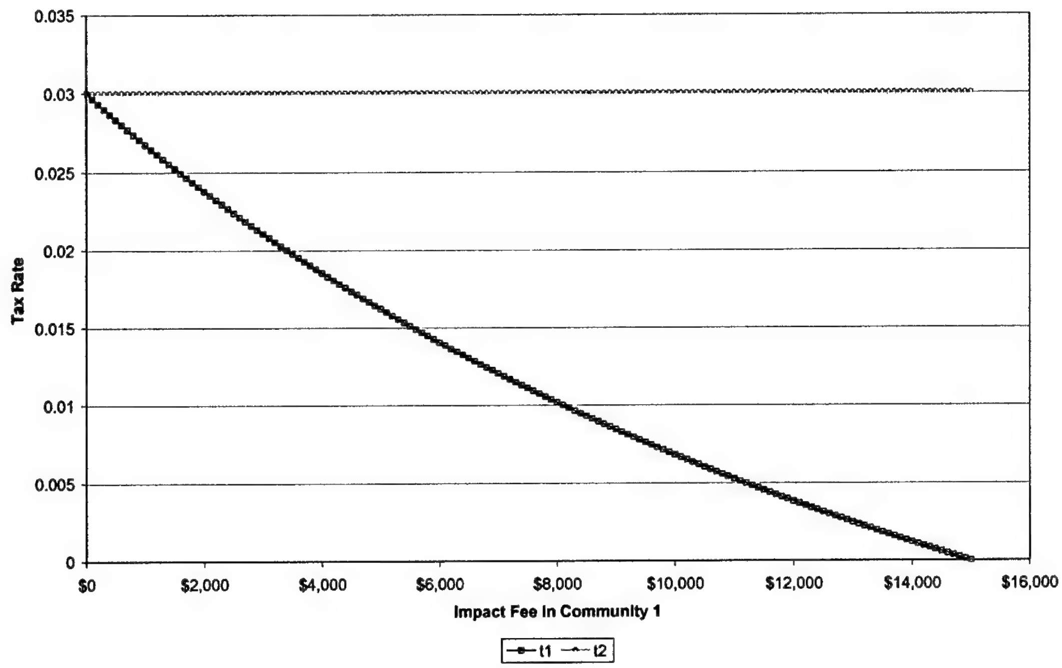


Figure 2.25: Tax Rate vs. Impact Fee in Community 1

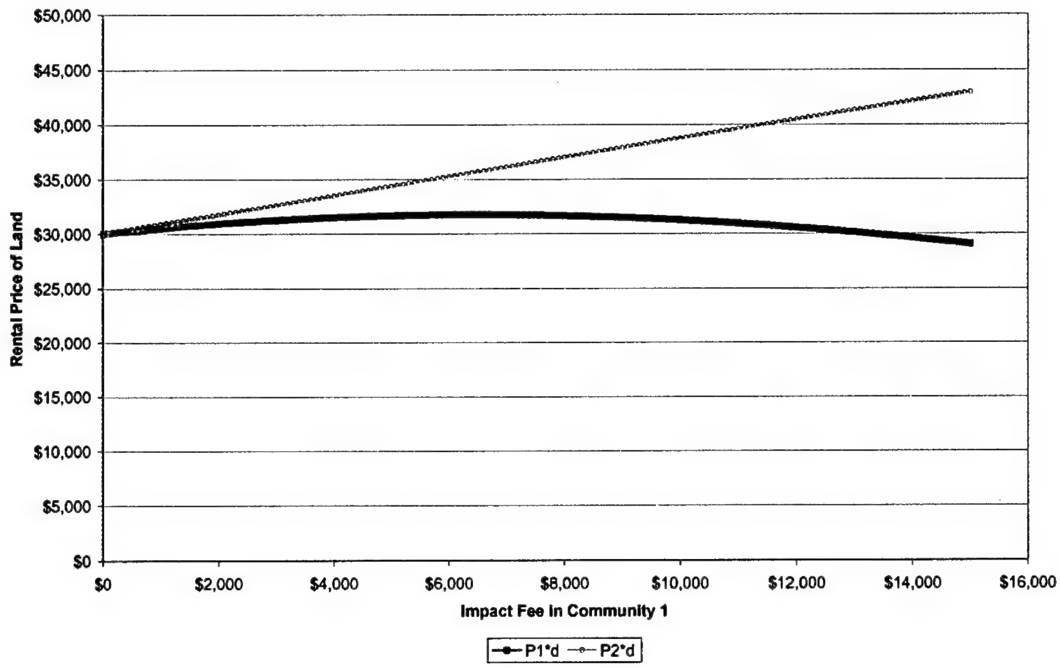


The price of land in community1, P_1, and therefore the before tax rental price of land, P_1d, is a more complicated function of the exogenous variables. This price adjusts at a rate necessary to keep P_1t_1 declining as new residents flee community 1 in response to the drop in income from the increase in the impact fee. The end result is that while P_1t_1 drops as the impact fee increases, P_1 and P_1d both increase until the impact fee reaches $6,400 and then declines over the remainder of the range of the impact fee.

The price of land in community 2 must rise. This is because an increasing amount of infrastructure must be fully financed by property tax revenue. Because the tax rate is constant in community 2, the only way for this to occur is for the price of land and therefore the rental price of land in community 2 to increase. Another way to think about the increase in the price of land in community 2 is to note that an increased number of new residents demand a fixed total land area. In order to

allocate a fixed amount of land to an increasing number of demanders, the price must rise. Figure 2.26 illustrates the relationship between the rental price of land and the impact fee in community 1.

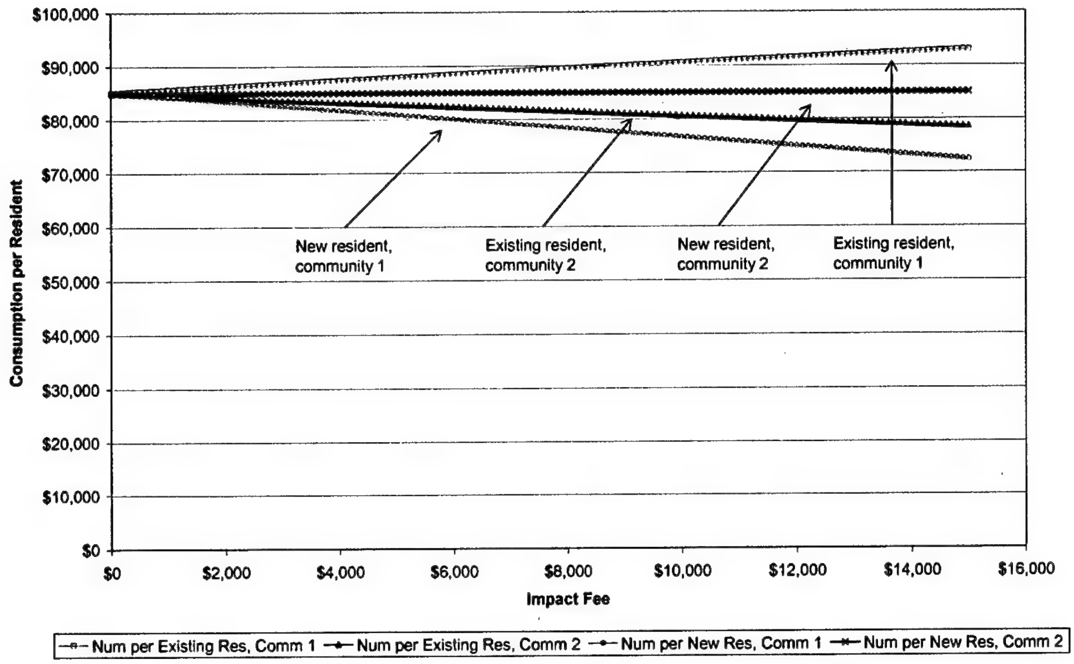
Figure 2.26: Rental Price of Land vs. Impact Fee in Community 1



Because the after tax price of land, $P_1(t_1+d)$, drops in community 1 when the impact fee is increased, existing residents can now afford more of the numeraire good. This occurs because land for existing residents is fixed and a drop in the total payment for land (including the tax) is used entirely for increased consumption. As mentioned earlier this is welfare improving for these residents. New residents in community 1, however, experience both a loss of income and a decrease in the after tax price of land when the impact fee is increased. This results in a drop in consumption of the numeraire good due to substitution away from relatively more expensive numeraire and a drop in consumption of the numeraire due to an income effect. New residents in community 1 suffer a decrease in welfare.

Existing residents in community 2 experience an increase in the after tax price of land. Unable to adjust land consumption in response to the price increase, they have income diverted away from consumption of the numeraire and to the payment for land. The increase in land price combined with a constant tax rate means that the property tax payment also increases and this further decreases consumption of the numeraire. Existing residents in community 2 therefore suffer a decrease in welfare. Finally, new residents of community 2 also experience an increase in the after tax price of land. While these residents economize on land as the impact fee in community 1 increases, the higher rental price of land does not relieve them of their tax payment. The amount of income devoted to land and the tax payment remains constant. Consumption of the numeraire therefore remains constant at the same time consumption of land decreases and welfare therefore decreases. Figure 2.26 illustrates the effect on consumption of the numeraire when the impact fee is increased in community 1.

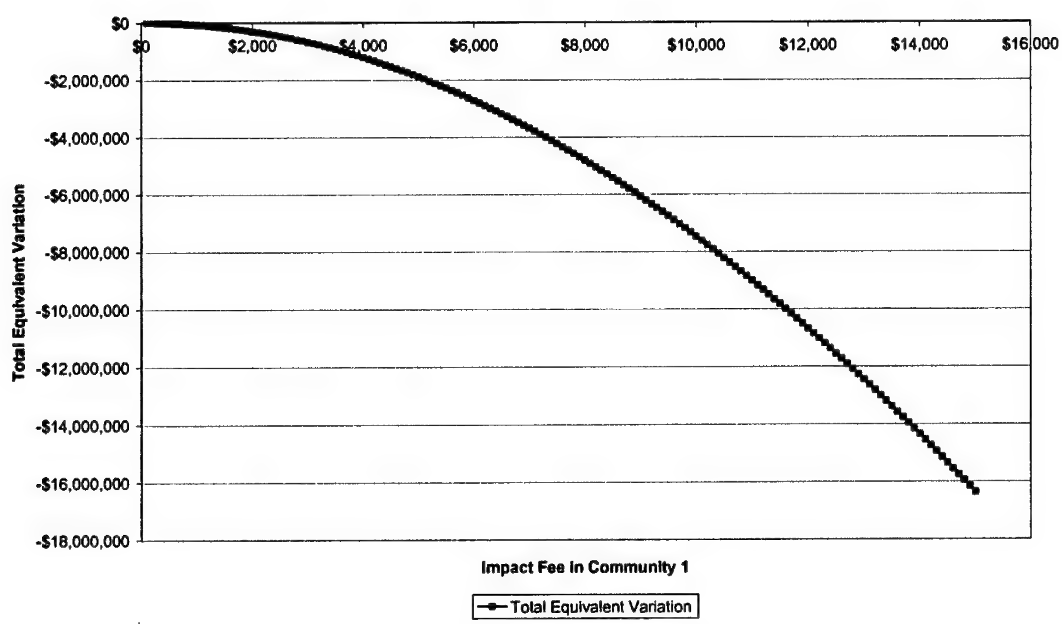
Figure 2.27: Consumption of Numeraire per Resident vs. Impact Fee in Community 1



To determine the overall effect on the welfare of all residents and land owners in the system it is necessary to remember that land is fixed for existing residents of both communities. While a money metric utility function can be used to measure equivalent variation for new residents of each community, it is an inappropriate method for measuring equivalent variation of existing residents. This is because existing residents will not be at a utility maximizing point after the change in impact fee is made. Existing residents cannot adjust land consumption in response to the change in the after tax price of land. The money metric utility function therefore underestimates the expenditure necessary to reach the new level of utility at the old prices and it also under estimates the expenditure necessary to reach the new level of utility at the new prices. Fortunately, the simulations compute the exact consumption bundle and new prices when the impact fee is changed. The expenditure necessary to

reach the new level of utility at the old prices is easily computed by multiplying the new consumption bundle by the old prices and the expenditure necessary to reach the new level of utility at the new prices is just the original expenditure before the change in the impact fee. While computations using only money metric utility functions reveal the unilateral adoption of an impact fee by one community to be welfare enhancing at all levels of the fee, the corrected computation of equivalent variation reveals that unilateral adoption of an impact diminishes welfare at all levels of the fee. Figure 2:28 depicts equivalent variation using corrected procedure.[7,8]

Figure 2.28: Total Equivalent Variation vs. Impact Fee in Community 1
(EV measured with corrected procedure)
(complete property tax is the reference point)



[7] All residents are weighted equally.

[8] All EV calculations in this chapter employ the corrected procedure.

2.6.2 *Effect on Utility and Endogenous Variables When Both Communities Simultaneously Switch from a Property Tax Regime to an Impact Fee.*

Given that switching to impact fee finance in one community has negative implications for welfare of existing residents of the community that continues to rely on property tax finance, a simulation was conducted to determine the result when both communities match fees in a competitive environment. This simulation shows that matching fees is welfare enhancing for existing residents of both communities and welfare reducing for new residents of both communities. Furthermore, maximum utility is achieved for existing residents when the impact fee charged each new resident is set equal to the respective infrastructure cost per resident. Additionally, the rental price of land continues to rise throughout the range of the impact fee. Figures 2.29 and 2.30 display these results.

Figure 2.29: Equivalent Variation per Resident vs. Impact Fee
I1 = I2

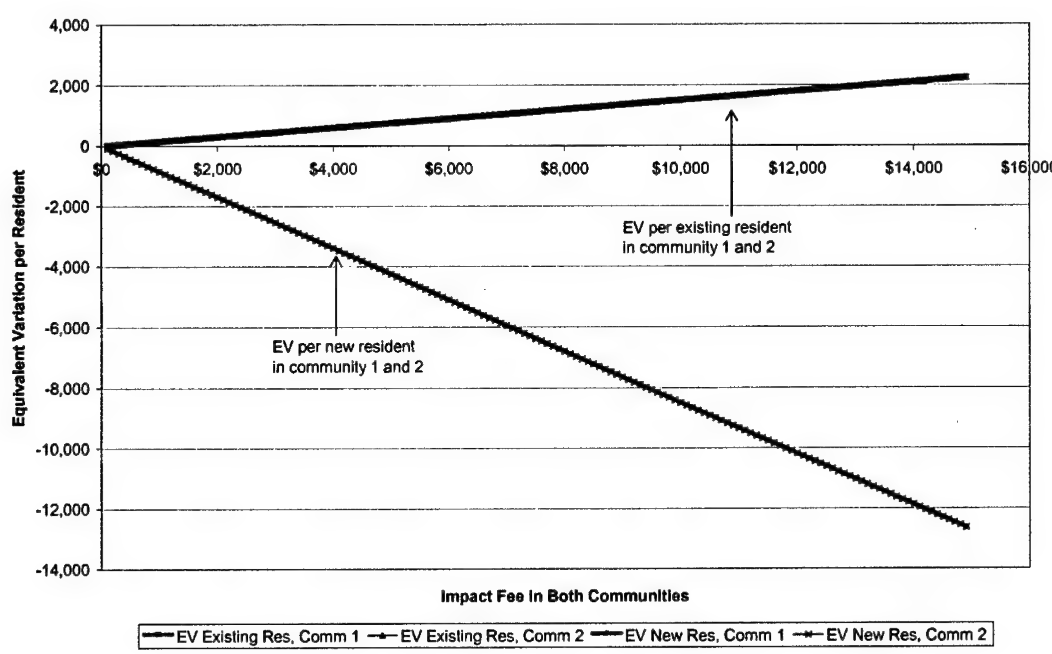
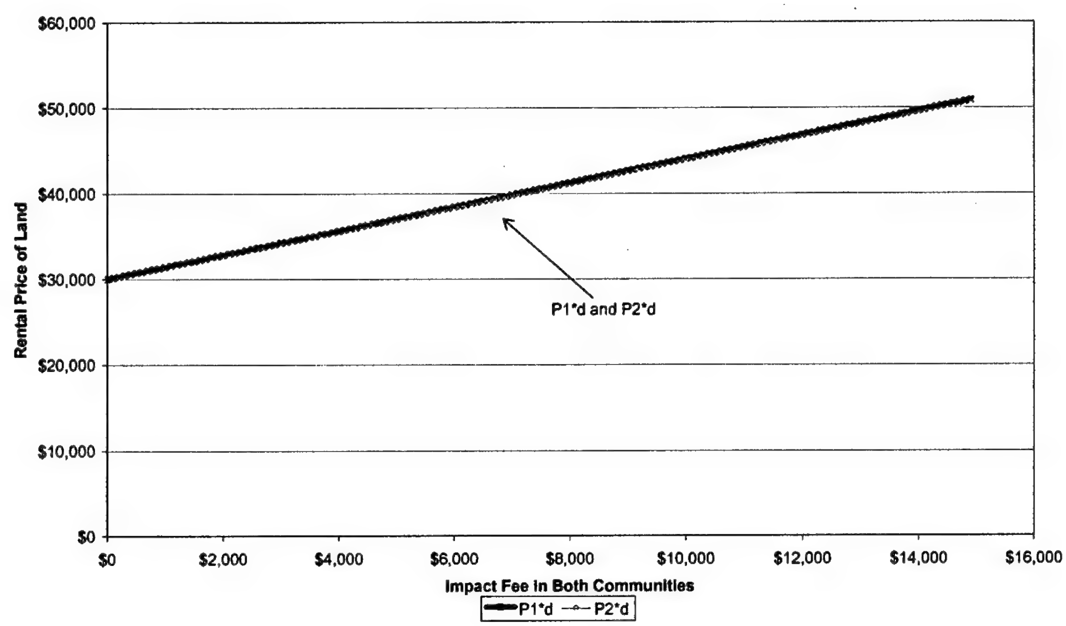


Figure 2.30: Rental Price of Land vs. Impact Fee
I1 = I2

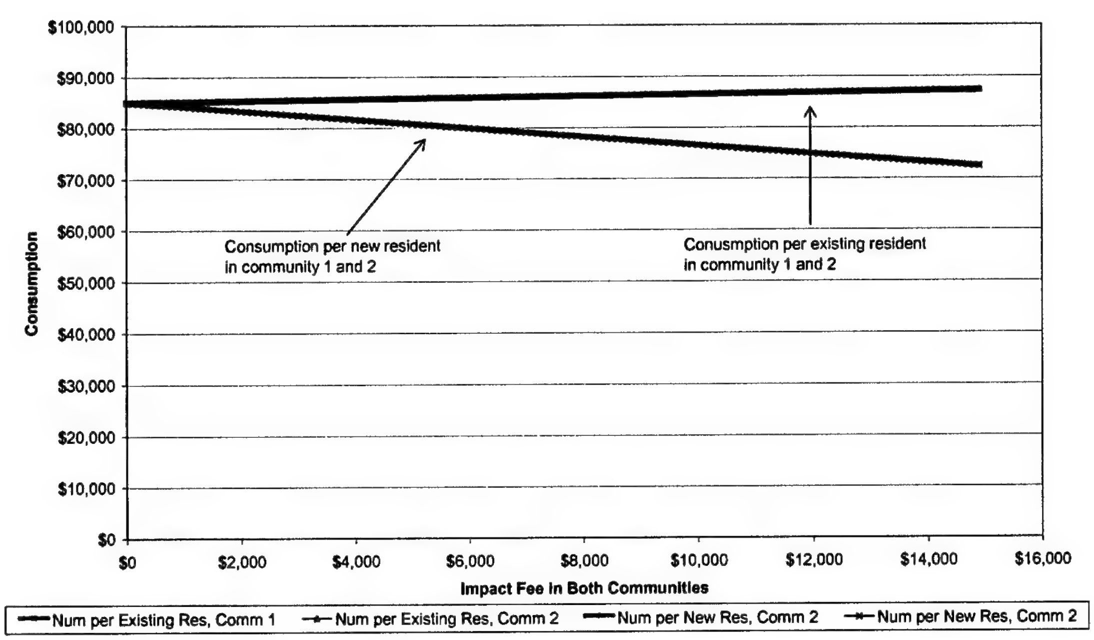


As the impact fee is symmetrically increased in both communities, new residents face the same drop in income regardless of the choice of community. Consequently, there is no way to escape the impact fee and new residents are distributed equally between communities. Given that the communities are symmetric, land per new resident is the same regardless of the choice of community and the rental price of land in each community is equal. The after tax price of land, however, must drop to compensate for the drop in income otherwise the income effect would imply a decrease in land consumption. The after tax price of land, $P_i(t_i+d)$ drops primarily because tax rates drop at a faster rate than land prices increase and the expression P_it_i declines as the impact fee rises. Intuitively one expects the tax rate to drop as the impact fee increases because less tax revenue must be raised. Equations (1) and (2) confirm this intuition. The increase in land price and therefore the rental

price of land is less intuitive as the price of land is a complex function of the exogenous variables in the system.

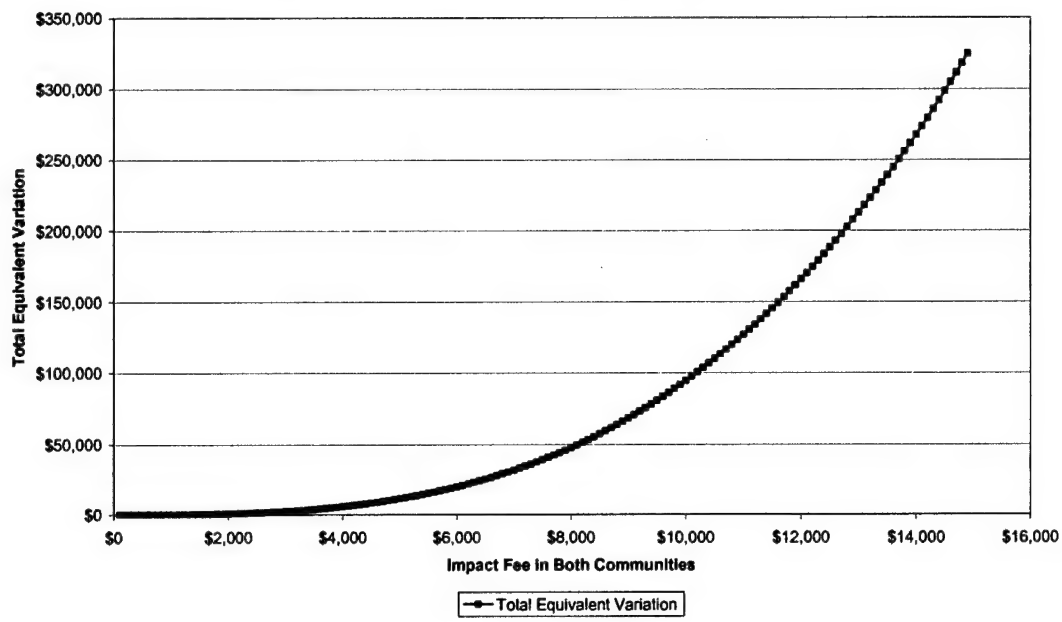
Existing residents of both communities are relieved of the tax burden associated with infrastructure finance and this reduction in tax payment is greater than the increase in the rental payment to land. Existing residents therefore consume more of the numeraire and their welfare increases. Another way to say this is that the after tax price of land has decreased. With a fixed amount of land consumption this releases income to be spent on the numeraire. New residents are not so lucky. The impact fee decreases income and this income effect combined with a substitution away from the numeraire due to the drop in the relative price of land causes consumption of the numeraire to decrease as the consumption of land remains constant. The net result for new residents is a drop in utility. Figure 2.31 illustrates the effect of an increase in the impact fee on the consumption of the numeraire.

Figure 2.31: Numeraire per Resident vs. Impact Fee
I1 = I2



The net effect on all residents and landowners in this simulation is positive even when equivalent variation is corrected for the fact that existing residents cannot adjust their land consumption in response to the decrease in the after tax price of land. Figure 2.32 shows the equivalent variation using the corrected procedure.

Figure 2.32: Total Equivalent Variation vs. Impact Fee
(equivalent variation measured with corrected procedure)
(complete property tax in both communities is the reference point)



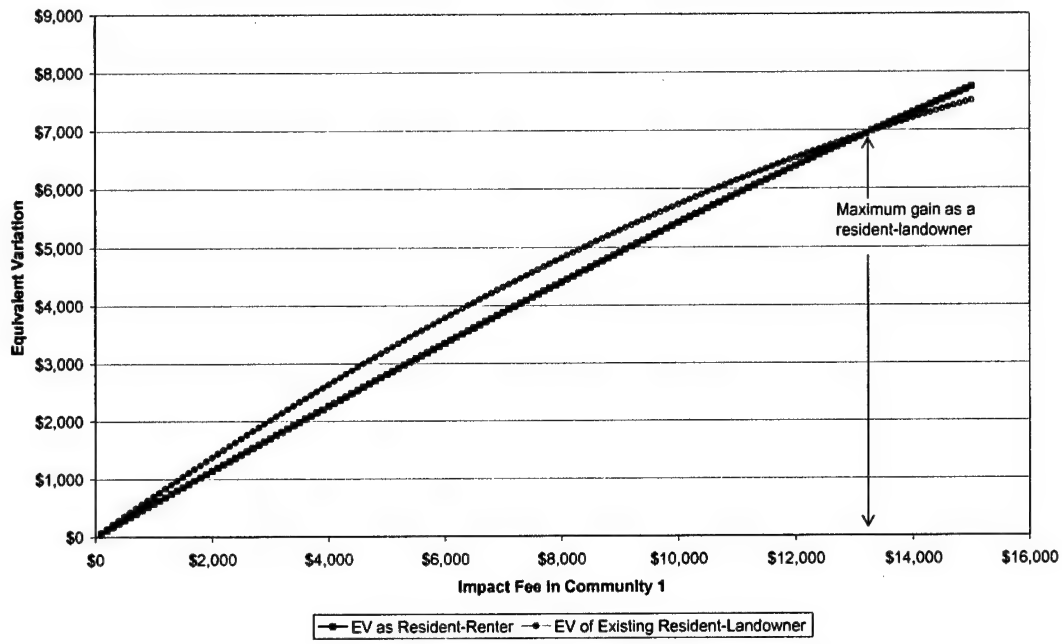
2.6.3 General Conclusions When Switching from Property Tax Finance to an Impact Fee

Under the assumption that only one community switches to an impact fee, the change in welfare is positive only for the existing residents of community 1 and negative for all other residents in the system. Absentee landlords in community 1 also benefit due to an increase in the rental price of land but only up to a point. The rental price of land reaches a maximum when the impact fee is $6400 and past that point the rental price begins to drop (see Figure 2.26). Once the impact fee reaches $13,200 the rental price of land is again equal to its value when only a property tax is

used to finance infrastructure. Absentee landlords in community 2 benefit from the impact fee in community 1 throughout the range of the fee.

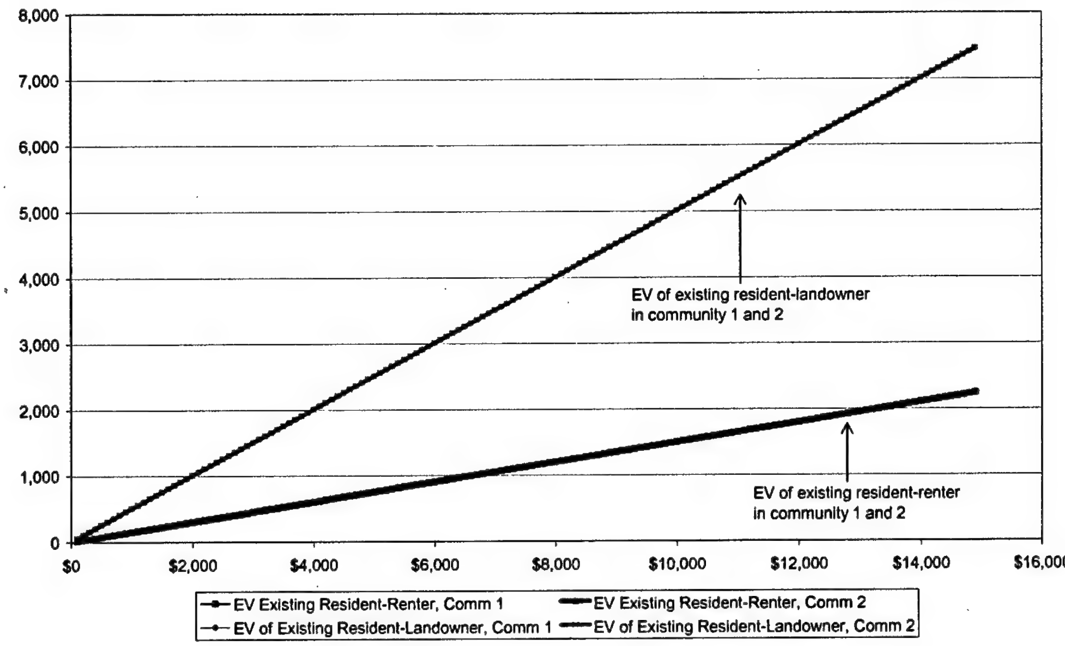
Assuming that the existing residents of a given community are the only individuals empowered to make a decision on how infrastructure is financed, it is apparent that the existing residents in community 1 will favor a fee that completely covers the infrastructure cost and do away with the property tax. This conclusion is mildly tempered if existing residents own their plot of land and nothing more. As residents they will gain from a reduction in the property tax and an increase in consumption. As land owners they will gain from a price appreciation that reaches a maximum at a $6,400 impact fee. Past this point price begins to drop and when the fee is high enough, they will experience a capital loss. Figure 2.33 compares the equivalent variation experienced by existing residents of community 1 if they simply rent versus the assumption that they both live in the community and own their individual plot of land and can experience the capital gain or loss associated with the impact fee. As figure 2.33 shows, these results do not significantly change when the assumption made that the existing residents of community 1 are landowner-residents. Landowner-residents still benefit from the impact fee throughout its range, but the maximum benefit occurs at a point where the impact fee is slightly less than the infrastructure cost per new resident. This implies that there is a strong incentive to adopt impact fees purely due to the financial incentive of reduced tax burdens and increased land prices. While this model only looks at the financing aspects of impact fees, it also indicates that reduction in new residents in community 1 due to impact fee finance may also act as a growth control and be favored on these grounds as well.

Figure 2.33 Equivalent Variation of Existinig Residents in Community 1 vs. Impact Fee in Community 1



The above analysis clearly ignores the reaction of existing residents in community 2 and since their welfare is decreased, one would like to know if there is some response that will ameliorate the effect of community 1's adoption of impact fees. The simulation in which communities match fees shows that the residents of community 2 should not only match community 1's fees but immediately impose a fee equal to the infrastructure cost per new resident. Figure 2.29 shows that existing residents in both communities benefit from matching the fee and setting it equal to the infrastructure cost. Absentee landlords also get the maximum capital gain from this policy. As figure 2.34 shows, this result again holds when the assumption is made that all residents own their individual plot of land. In both cases existing residents benefit and new residents lose.

Figure 2.34: Equivalent Variation of Existing Residents in Community 1 and 2 vs. Impact Fee I1=I2



While there is no redistribution of residents when the impact fee is imposed in both communities, it is in the best interest of the existing residents of both communities to adopt impact fees. The results of this model indicate that once one community adopts impact fees others will follow.

Table 2.5 summarizes the payoff to a resident-renter in each community when each community independently chooses to use either complete property tax finance or complete impact fee finance of new infrastructure. Resident-renters are chosen as the reference group because it is assumed that only they can change the financing scheme through a voting mechanism. As can be seen in Table 2.5, the dominant strategy of each resident-renter is to enact complete impact fee financing. If each community is faced with a referendum to enact impact fees then the fee should pass unanimously and the resident-renters receive the payoffs in the lower right-hand box.

Table 2.5: Equivalent Variation Payoffs to Existing Resident-Renters Under Complete Property Tax and Complete Impact Fee Regimes

		Community 2	
		Impact Fee = $0	Impact Fee = $15,000
Community 1	Impact Fee = $0	$0 $0	$7,738 -$6,457
	Impact Fee = $15,000	-$6,457 $7,738	$2,250 $2,250

Table 2.6 summarizes the change in land price associated with each community's choice of financing mechanism. If one operates under the assumption that landlords do not live in the community and do not have a say when the finance mechanism is chosen, then adoption of an impact fee which completely covers the infrastructure cost by the community in which they own land is detrimental if the other community does not adopt a fee. Notice that this conclusion is qualified by the fact that fees up to $13,200 do increase the rental price of land. However, since resident-renters of both communities have a dominant strategy to enact the full fee, absentee landlords will receive the payoff in the lower right-hand box. Therefore owners of land in both communities will gain along with resident-renters of both communities.

Table 2.6: Change in the Per Acre Rental Price of Land Under Complete Property Tax and Complete Impact Fee Regimes

		Community 2	
		Impact Fee = \$0	Impact Fee = \$15,000
Community 1	Impact Fee = \$0	\$0 \$0	-\$,954 \$12,914
	Impact Fee = \$15,000	\$12,914 -\$954	\$21,000 \$21,000

Finally, Table 2.7 illustrates the payoffs if one assumes that each resident owns their individual plot of land. As Figure 2.30 indicates, when both communities match impact fees, the price of land continually rises and reaches a maximum in both communities when the fee is set equal to the infrastructure cost. Resident-owners receive a capital gain from impact fee finance but they also must pay additional rent to themselves. The capital gain and the increased rental payment are considered a wash in this situation. Another way to think about this is to consider resident owners as paying a perpetual mortgage at a fixed rate. When the price of land rises, the mortgage payment does not change. However, because these resident-owners are immobile they also cannot realize the capital gain on their land. Therefore the only gain to resident-owners from a shift to impact fee finance is the removal of the tax payment for new infrastructure. Given this situation resident-owners still have a

dominant strategy to shift from financing infrastructure with a property tax to complete impact fee finance.

Table 2.7: Equivalent Variation Payoffs to Existing Resident-Owners Under Complete Property Tax and Complete Impact Fee Regimes

		Community 2	
		Impact Fee = \$0	Impact Fee = \$15,000
Community 1	Impact Fee = \$0	\$0 \$0	\$7,500 -\$3,229
	Impact Fee = \$15,000	-\$3,229 \$7,500	\$7,500 \$7,500

Chapter 3

Empirical Analysis of the Incidence of Impact Fees

3.1 Introduction

The theoretical model of Chapter 2 sheds some light on the incidence of impact fees on land prices when existing residents are immobile and land satisfies the consumer's need for housing. A key result of the theoretical model is that there is an incentive for all communities to adopt impact fees and set the fee to equal the cost of infrastructure provision. To the extent that communities follow these incentives, the before tax rental price of land in all communities will rise (see figure 2.31). If however, some communities do not adopt fees, then the before tax rental price of land in the community that adopts the fee is dependent on the level of the fee (see figure 2.26). The incidence of impact fees is therefore an empirical matter. Furthermore, if the incidence of the fee is negative for a given community, the model of Chapter 2 suggests that the fee may not be set optimally in relation to the fee of neighboring communities.

When moving from the theoretical model to the empirical model, it should be noted that various assumptions and data limitations will necessarily alter the context of fee incidence. Land is only one component of housing and when fee incidence is considered one is more concerned about the overall affordability of housing than incidence on land alone. However, if fees are imposed on land then the land component of housing should be affected and this should influence the overall sale

price of housing. Additionally, the method in which fees are applied also alters the context of fee incidence. In practice, almost all impact fees are charged to land developers (Brueckner 1997) and not to the eventual home buyers. This places empirical impact fee analysis squarely in a traditional tax incidence framework. Indeed, most empirical work analyzes impact fee incidence strictly as a tax placed on housing and concludes that housing prices will rise (Delaney and Smith 1989, Singell and Lillydahl 1990). In order to formalize the empirical results, Watkins (1999) develops a theoretical model entirely within the tax incidence framework and comes to the conclusion that fees will be "on-passed" to housing based on the elasticities of supply and demand.

This framework, however, seems unsatisfactory for several reasons. Traditional tax incidence analysis suggests that fees will not increase price by more than one dollar for every dollar of tax. This ignores the possibility that impact fees may have demand side effects. Impact fees may create an amenity by signaling that a community will not permit the level of public goods to deteriorate as a community grows. This increase in demand combined with the attempt by developers to pass on fees may actually cause price to increase by more than the fee. Furthermore, Skidmore and Peddle (1998) suggest that in some cases impact fees may actually increase the supply of housing by allowing development in cases where infrastructure would not be provided without an impact fee. Fischel (2001) echoes this idea. If this occurs then the price may actually decrease. The standard tax incidence framework is also lacking because it generally ignores the effect of property tax on home prices. There is a rich literature on the effect of property tax on housing prices which

concludes that property tax is a significant variable in price determination that should not be omitted from an empirical model.[9]

These considerations suggest that any empirical investigation of the effect of impact fees on housing prices should a) analyze a system of communities, b) allow for negative incidence of impact fees, c) consider cases where the fee causes price to change by more than the amount of the fee, and d) include a property tax variable to account for property tax capitalization. Negative coefficients on impact fee variables and incidence greater than the fee would indicate that more than simple tax incidence is at work.

The empirical model developed in this chapter is embedded in a standard hedonic framework of housing prices that also allows for property tax capitalization. While property tax capitalization is not the focus of this research, it is important to include it to properly capture the demand effects of the impact fees and to correctly specify the model. The model therefore includes standard housing characteristics, community variables that proxy for public service levels, year dummies to account for year specific effects, a property tax capitalization variable, variables to measure the effect of the impact fee on the general price level for each community, and variables to measure the incidence of the impact fee on new homes in each community. Additionally, because the premium on new homes may vary from community to community, a dummy variable for newness is interacted with each community variable.

[9] See Yinger, Bloom, Borsch-Supan, and Ladd, 1988 for a review of the capitalization literature.

3.2 Data

The communities used to investigate the incidence of impact fees on before tax housing prices are located northern El Paso County, Colorado. This area contains communities that have no impact fees and communities that have a long history of fee use. Some communities that use fees have also tended to adjust them over time to adjust for inflation or as growth rates increased. Sale data from 1994 to 1999 was collected on single family detached homes from the El Paso County Assessor's Office. The data set includes nominal sale price, year sold, housing characteristics, and the property tax district that the parcel is located in. Excluded from the data set are all non arms-length transactions, homes older than 30 years of age, and homes with greater than five acres of land. These properties were considered outliers in the data set and were also a small percentage of the total sales transactions. The remaining data set includes 12,306 sales transactions of homes located in the two northern-most school districts in the county. These areas can be considered substitutes for each other. Data on expenditure per student for each year and school district was collected from the Colorado Department of Education and used as an instrumental variable for taxes in some of the models. Other data includes property tax rates for the year of sale, collected from the El Paso County Treasurer's Office; and nominal impact fees, collected from the various water and sanitation districts or city responsible for administering the property. All nominal values were converted to constant year 2001 dollars using the Denver-Boulder CPI.

Two variables needed to be constructed. First it was necessary to group properties into community variables to measure fiscal and amenity effects. Wherever

possible, community variables are defined by existing municipal boundaries. However, in the case of homes in the City of Colorado Springs, the geographic area was large and encompassed many neighborhoods. Here, communities are defined by neighborhoods or subdivisions.

The second variable that had to be constructed was the present value of annual tax payments for the linear versions of the model. Unfortunately, neither the Assessor's Office nor the Treasurer maintained easily accessible historical data files detailing the annual tax payment on properties in the year they sold. In order to estimate the tax payment in the year a property was sold, a procedure mimicking the county assessment process was used. The county computes assessed values based on market values of homes sold in an 18 month period prior to the assessment date. The market prices are then used determine price factors for various components of the home in the assessment process. While the county assessors did not explicitly state that hedonic price factors from regression analysis were used in the assessment process, interviews were able to reasonably reconstruct the home characteristics used in the process. To mimic the assessment process, sale prices from an 18 month period predating the tax payment to be estimated were regressed on housing characteristics from that 18 month period. This data was readily available and the coefficients from these regressions were then used to predict an assessed property value for specific homes. The assessed value was then multiplied by the tax rate in the year the home was sold to obtain an estimated property tax payment. Finally, the estimated tax payment was divided by the real discount rate (assumed to be 0.03) to find the present value of the tax stream.

Table 3.1 below summarizes and explains the variables. Variables interacting newness and community; newness, community and impact fee; newness, community and lagged impact fee; newness and impact fee only; and newness and lagged impact fee are not listed for brevity.

3.3 Behavioral Assumptions, Functional Forms, and Econometric Techniques

While the primary concern of the paper is to estimate the effect of impact fees on home prices, the functional form and econometric technique used to estimate the model is driven by the behavioral assumptions behind the property tax capitalization variable. Two possible behavioral assumptions are hypothesized and two different estimation methods are employed.

3.3.1 Method 1

One way that individuals may estimate the present value of property tax payment when they purchase a home is to take note of the current property tax payment, assume that the payment will continue into the future, and apply a suitable discount rate. The property tax payment for existing homes is published in the Multiple Listing Service or is usually available from the real estate agent. Individuals then bid for homes based on their judgment of the present value of the tax payment in relation to the expected stream of public services. Any under or over payment is capitalized into the bid.

Table 3.1: Variable Summary

Variable	Explanation	Obs.	Mean	Std. Dev.	Min	Max
rsale	real sale price in yr. 2000	12306	227030.50	81862.90	65131	952209
pvestrtax	present value of future tax payments	12306	68496.60	23796.97	8411	247722
lotsize	lot size in sq. ft.	12306	20772.29	36084.61	1500	217800
fsqft	finished square footage	12306	2485.06	902.99	660	7708
ufsqft	unfinished square ft.	12306	554.67	546.18	0	3164
baths		12306	2.99	0.78	1	8
gararea	garage area in sq. ft.	12306	532.43	152.04	0	1500
twostory	style dummy	12306	0.61	0.49	0	1
ranch	style dummy	12306	0.21	0.41	0	1
otherstyle	style dummy	12306	0.18	0.39	0	1
age		12306	6.92	6.80	0	30
new		12306	0.27	0.45	0	1
age1to5	age category	12306	0.24	0.42	0	1
age6to10	age category	12306	0.17	0.38	0	1
age11to15	age category	12306	0.20	0.40	0	1
age16to20	age category	12306	0.08	0.27	0	1
age21to30	age category	12306	0.04	0.19	0	1
d94	year dummy	12306	0.17	0.38	0	1
d95	year dummy	12306	0.15	0.36	0	1
d96	year dummy	12306	0.17	0.38	0	1
d97	year dummy	12306	0.15	0.36	0	1
d98	year dummy	12306	0.19	0.39	0	1
d99	year dummy	12306	0.16	0.37	0	1
academy	community dummy	12306	0.01	0.10	0	1
donala	community dummy	12306	0.07	0.26	0	1
monument	community dummy	12306	0.01	0.10	0	1
palmer1	community dummy	12306	0.01	0.12	0	1
palmer2	community dummy	12306	0.01	0.08	0	1
woodmoor	community dummy	12306	0.09	0.29	0	1
arrowwood	community dummy	12306	0.03	0.16	0	1
blackforest	community dummy	12306	0.02	0.13	0	1
falcon	community dummy	12306	0.00	0.04	0	1
dwfire	community dummy	12306	0.06	0.24	0	1
nofire	community dummy	12306	0.01	0.09	0	1
cs1	community dummy	12306	0.24	0.43	0	1
briargate	community dummy	12306	0.35	0.48	0	1
norwood	community dummy	12306	0.04	0.20	0	1
peregrine	community dummy	12306	0.04	0.21	0	1
rfee	real impact fee in yr. 2001	12306	5870.26	3366.72	0	15323
lrfee	real impact fee from year prior to sale	12306	5913.86	3257.35	0	15322

Endogeneity between the property tax variable and the sale price may arise in the empirical model when this procedure is used. The degree of endogeneity depends on the extent that the assessed value of the home, and therefore the property tax payment, is related to the sale price of the home. Fortunately, this problem is well documented in the property tax capitalization literature and can be dealt with using instrumental variables.[10] In the instrumental variable models that follow, the real expenditure per student by the school district is used to instrument the property tax variable.

The instrumental variable models are all of the following form:

$$\begin{aligned} V &= A + \beta_1 \left(\frac{T}{i}\right) + \Sigma(\alpha_k C_K) + \Sigma \nabla_q year_q + \Sigma \theta_j community_j \\ (1) \qquad &+ \Sigma \phi_j (community_j * new) + \Sigma \lambda_j (community_j * fee_j) \\ &+ \Sigma \delta_j (community_j * fee_j * new) + \varepsilon \end{aligned}$$

V represents the sale price of the home. A is a constant. T/i is the present value of the future stream of property tax payments at the time of sale. i is the real discount rate which is assumed to be three percent. C_k is a vector of housing characteristics. Year is a vector of year dummies. Community is a vector of community dummies. Fee is the fee in the given community at the time of sale, and new is a dummy variable indicating newness. The community variables proxy for public services. The community variable interacted with the new variable is intended to isolate any unique premium associated with newness in the given community. The community variable interacted with the fee should pickup any fee effect on the community as a

[10] For example see Yinger, Bloom, Borsch-Supan, and Ladd, 1988

whole and the community variable interacted with the fee and new variable should pick up any separate effects of the fee on new housing within the given community.

Since this model is likely to exhibit heteroscedasticity with respect to the size of the home as well as other unknown forms of heteroscedasticity, White's corrected variance covariance matrix is employed. This avoids the necessity of transforming the variables with respect to square footage, corrects for unknown forms of heteroscedasticity, and leaves the coefficients in a form which can be easily interpreted.

3.3.2 Method 2

The second method that may be employed by buyers to estimate property tax payment hypothesizes that buyers form their expectation of the tax payment from the current property tax rate and the sale price negotiated with the seller. In this case the property tax payment is simply the sale price multiplied by the tax rate. The buyer then extrapolates this payment into the future and discounts by an appropriate rate.

Equation (1) is reformulated below to illustrate the econometric problem associated with estimating property tax capitalization based on tax rates instead of property tax payments. In this formulation the tax payment, T, is equal to the tax rate, t, multiplied by the sale price, V.

$$
\begin{aligned}
(2) \qquad & V = A + \beta_1\left(t\frac{V}{i}\right) + \Sigma(\alpha_k C_K) + \Sigma\nabla_q year_q + \Sigma\theta_j community_j \\
& + \Sigma\phi_j(community_j * new) + \Sigma\lambda_j(community_j * fee_j) + \\
& \Sigma\delta_j(community_j * fee_j * new) + \varepsilon
\end{aligned}
$$

β_1 still estimates the capitalization rate, but now the present value of the tax payment, $t\frac{V}{i}$, is endogenous by definition. An estimation of method two with ordinary least squares yields biased coefficients. Fortunately the capitalization literature also deals with this problem and suggests reformulating the linear model into the following nonlinear form.

$$
\begin{aligned}
V = \left(\frac{i}{i-\beta_1 t}\right)&[A + \Sigma(\alpha_k C_K) + \Sigma \nabla_q year_q + \Sigma \theta_j community_j \\
(3) \qquad &+ \Sigma \phi_j (community_j * new) + \Sigma \lambda_j (community_j * fee_j) \\
&+ \Sigma \delta_j (community_j * fee_j * new) + \varepsilon]
\end{aligned}
$$

This method has the added feature of eliminating intrajurisdictional property tax capitalization. Since the buyer bases assessed value on true market value, there is no longer any assessor error in the model. Now the property tax variable is only estimating the effect on home prices when different communities provide the same level of public services at different prices not the error introduced within a community when assessors value like houses differently. Given this difference between the two methods it is likely that they will yield different estimates of capitalization.

3.3.3 Identification of the Coefficient of the Impact Fee Variable

The impact fee is assumed to be set by each community based on the level of infrastructure provided. All communities that do not charge a fee do not provide city water and sanitation services and these communities rely on well and septic. The fee may vary in a community over time if that community decides to provide a different level of infrastructure at different periods of time. However, since water and

sanitation services tend to be standardized without much variation in quality, variation in the fee within a community for reasons of quality is unlikely. It is more likely that fees vary within a community due to failure to adjust adequately for inflation. If the assumption is dropped that the fee is set in proportion to the level of infrastructure cost and is set based on some other factor (e.g. housing demand), then there may be room for more variation of the fee within a community over time. In practice, the impact fee exhibits more variation between communities. The cost of providing standardized water and sanitation services depends on lot size and housing density. Communities with larger lots and more custom homes tend to have higher infrastructure costs and higher impact fees. Because there is more variation between communities than within communities over time, the coefficients on both the community and impact fee variables may be measuring the same thing. This will not only lead to multicollinearity between the coefficients, but also make it difficult to disentangle the effects of the community variable (a proxy for public service and amenity effects) from the effect of the impact fee.

3.4 Estimation and Results

Eleven models were estimated using both instrumental variables and non-linear least squares. The primary models estimated follow the specification in equation (1) and (3). In these two models the newness characteristic is interacted with the community variable to see if the magnitude and significance varies between communities. Likewise the real impact fee is interacted with communities to see if the general effect on the price level varies between communities, and finally the real

impact fee and newness characteristic is interacted with communities to investigate the effect of the impact fee on new homes between communities.

All other models are estimated to check the robustness of the two primary models. Two variants of the model constrain the capitalization variable (pvestrtax) to -1.0 and to -0.6 respectively. The value of -1.0 is the theoretical case of perfect capitalization and the value of -0.6 is an average of the capitalization values found in the most recent capitalization literature (Palmon and Smith 1998b). Other models replace the real impact fee at the time of sale with the real impact fee one year prior to the sale. Since the impact fee is normally paid at building permit issuance and this may occur up to one year in advance of the sale, the thought is that the lagged fee may be a more appropriate variable to use. Finally, some models replace the age variable with age categories. The reason for this is to check for robustness if one suspects that age does not follow a linear relationship.

Complete model results are listed in Appendix C. Coefficients on all fee variables for the full instrumental variable model and full non-linear model are listed in Table 3.2. All models and methods of estimation are highly congruent with respect to the primary explanatory variables of lot size, finished square footage, unfinished square footage, number of baths, garage square footage, house style, and age. The coefficients on the variables all have the expected sign and a reasonable magnitude regardless of estimation method or model specification. Most of these variables with the exception of the number of baths and the style variables are highly significant at the five percent level. The coefficients of the primary variables do not vary considerably when lagged impact fees are used or when the age variable is replaced

with age categories. In fact, the models that employ age categories indicate that entering age into the estimation in a linear fashion is appropriate.

The point estimates for the capitalization variable range from -0.31 to -1.08. The sign agrees with the theoretical prediction and the magnitude is within the results of previous empirical studies. While the capitalization variable is never significant at conventional levels, one interesting finding is that the nonlinear models produce relatively more significant coefficients and coefficients that are smaller in absolute magnitude than the instrumental variable method. Whether this is due to the fact that intrajurisdictional capitalization is eliminated from the nonlinear models or that the nonlinear models did not have a precise tax payment to calculate the variable (as well as a perfect instrument) is a matter of speculation.

The year and community variables all tended to be congruent across models. The point estimates for the coefficients on the year variables were all positive and of reasonable magnitude. This conforms to the theory that the local housing market was coming out of a relatively slow period relative to the base year of 1994 and responding to both job growth and immigration into the area. However, no definitive conclusions can be drawn since significance levels vary from year to year and to a lesser extent from model to model. While the coefficients on the community variables are congruent across models, almost all were negative in relation to the base community of Donala. Furthermore the coefficients tended to be significant. The puzzling issue is that these coefficients also tended to be quite large relative to the average sale value in the data set and it is unlikely that the magnitude of the coefficients reflects the actual fiscal and amenity differences between communities.

The interaction of the community variable with the dummy variable for newness also yielded ambiguous results. While the signs of the coefficients were mostly positive as expected, in many cases the coefficients were insignificant. Additionally, some coefficients were negative. In cases where the coefficients were significant, the magnitude of the coefficient seems unusually large.

The impact fee interacted with the community, and the fee interacted with the community and newness characteristic are the primary focus of this investigation and these coefficients are listed in Table 3.2 below along with the coefficient on the property tax capitalization variable.

Table 3.2: Model Results*

	pvestrtax	academy rfee	donala rfee	monument rfee	palmer1 rfee	palmer2 rfee	woodmoor rfee	cs1 rfee	briargate rfee	norwood rfee	peregrine rfee
IV Model	-0.80	10.44	-9.94	0.73	1.23	0.20	-22.01	43.67	59.34	73.60	76.91
	0.62	*0.44*	*0.01*	*0.69*	*0.86*	*0.93*	*0.01*	*0.10*	*0.03*	*0.01*	*0.08*
NL Model	-0.32	15.52	-10.09	0.95	-1.02	-0.68	-23.49	51.48	69.31	82.85	87.70
	0.21	*0.39*	*0.26*	*0.92*	*0.88*	*0.89*	*0.01*	*0.04*	*0.00*	*0.09*	*0.19*

	academy new rfee	donala new rfee	monument new rfee	palmer1 new rfee	palmer2 new rfee	woodmoor new rfee	cs1 new rfee	briargate new rfee	norwood new rfee	peregrine new rfee	R^2
IV Model	-30.84	11.95	5.15	-9.19	-3.68	0.98	69.84	18.01	39.95	122.81	0.34
	0.01	*0.01*	*0.03*	*0.26*	*0.26*	*0.88*	*0.26*	*0.43*	*0.06*	*0.03*	
NL Model	-32.15	13.92	5.72	-9.20	-3.40	-0.18	79.44	17.32	46.65	145.08	0.84
	0.61	*0.25*	*0.72*	*0.51*	*0.79*	*0.99*	*0.08*	*0.57*	*0.68*	*0.14*	

*Significance levels are listed below the coefficients.

The coefficients on the capitalization variable (pvestrtax) are of the expected sign and reasonable magnitude based on previous studies. However, the coefficients are not significant. This is not surprising and may be due to the notorious difficulty of measuring public service levels and the method of estimating the tax payment in the instrumental variable model. The coefficient in the non-linear model is of higher significance than the instrumental variable model. This may be due to the fact that actual tax rates were available and the capitalization variable is not distorted by estimating the property tax. The magnitude of the coefficient is also lower and may be attributed to the fact that there is only interjurisdictional capitalization because assessment error has been eliminated. However, too much can be made of this conjecture since the variable is still insignificant.

If one hypothesizes that impact fees act as a tax as Watkins (1999) suggests, then fees should always increase prices or as a minimum, have no effect. Fees should also increase prices if the fee is used to offset taxes or they create some other benefit that make the community attractive. If, on the other hand, the fee brings forth an increase in supply by permitting land that otherwise would not be developed to be developed, this supply response should lower price. To date almost all the empirical literature on impact fees has modeled the fees as a tax and posited a positive relationship between fees and price. Furthermore, if only tax incidence is occurring, then housing prices should not rise by more than the fee itself. Singell and Lillydahl (1990) found that fees increased housing prices by almost three times the amount of the fee. The results of this model provide evidence that more than tax incidence is occurring. The negative and significant coefficients on some of the community variables interacted

with the fee and interacted with the fee and newness should not occur in a tax incidence model. Tax incidence models should also see prices rise by no more than the fee even when the fee is fully passed on the buyer. The fact that the coefficients on the fee variables are greater than one in absolute value and significant for a number of communities, suggests that other demand and supply responses may be compounding the effect of the fee.

One final consideration should be mentioned. It was assumed that the impact fee is an exogenous variable that does not depend on price of housing estimated in the reduced form equations (1) and (3). If however, fees also depend on growth (as indicated by the change in price associated with the year dummy variables), and communities are setting the fees based not only on infrastructure cost but also growth, then the fee may be an endogenous variable. In this case the structural equation for the impact fee may be over-identified. There is some evidence that impact fees responded to growth in the northern most communities from 1994 to 1995. Real fees for some of these communities jumped dramatically. However, outside of a few communities and this time period, the real impact fee in most communities declined slightly. This indicates that the variation in the impact fee within a community in this data set appears to be mostly due to inadequate adjustment for inflation rather than a response to rapid growth.

Overall the results of this model provide some support for rejecting simple models of tax incidence. However, community variables do not seem to be accurately measuring fiscal and amenity effects. On the positive side, the coefficients on the

primary explanatory variables of housing price are significant, of the expected sign, and robust across models and methods of estimation.

3.5 Estimation and Results of a Reformulated Model

Investigation of the models above revealed that all of the community variables interacted with newness were highly correlated (> 0.99) with the same community variables interacted with newness and the impact fee. This led to a second effort to estimate the effect of impact fees on the general price level in the entire sample and on the price of all new homes in the sample. In this estimation the community and newness interaction terms as well as the community, newness, and impact fee interaction terms were dropped from the model. The community variable was included to account for location specific effects. While this model is not capable of measuring individual community effects of the impact fee it can gauge the overall effect of fees on the system of communities. Additionally, the model of chapter two indicates that an increase in impact fees in neighboring communities should increase the price of housing in a given community. Given this finding a variable for the average impact fee of surrounding communities was added to test this hypothesis. A positive coefficient on this variable would tend to confirm the hypothesis.

The model was still estimated with both instrumental variable and nonlinear techniques. Additionally, estimations that checked for robustness with respect to the linearity of age and the use of lagged impacted fees were estimated. In all eight different estimations were accomplished and are listed in Appendix D.

Again, all methods of estimation and model variations are highly congruent with respect to the primary explanatory variables of lot size, finished square footage, unfinished square footage, number of baths, garage square footage, house style, and age. The coefficients are of the expected sign and magnitude and are highly congruent with the coefficients from the estimations interacting community, newness, and the impact fee.

The point estimates for the capitalization variable range from -0.24 to -1.44 and are not significant at conventional levels. As in the models estimated in section 2.4, the point estimate for the nonlinear technique is smaller in absolute magnitude and more significant than the instrumental variable technique. The year coefficients are not as congruent across models as in section 2.4, but where the coefficients are somewhat incongruent they are also highly insignificant. The biggest difference found when dropping the interaction terms is that the community variables now appear to be of a more reasonable magnitude. On average no community differs in price by more than $120,000 compared to the base community of Donala. Dropping the interaction terms appears to allow the community variables to more accurately estimate the fiscal and amenity effects associated with specific locations. Adding the average fee of all other locations (avgrfee) yielded mixed results. The expectation was that the higher the average fee in neighboring all other communities the higher would be price in the given community. This turned out to be true in all the estimations except those using lagged fees. All the estimations using lagged fees yielded negative point estimates for the coefficient on the average fee. All

estimations of this coefficient, however, were highly insignificant and no conclusion can be drawn about the effect of the level of fees in other communities.

Table 3.3 reports the coefficients on the capitalization variable and fee variables for the primary instrumental variable model and nonlinear model. The impact fee (rfee) tends to lead to a general increase in the price level of all homes. However, the coefficient on this variable is never significant at conventional levels. The strongest result is the effect of the impact fee on new homes in the entire sample. The coefficient on the impact fee interacted with the newness variable (rfeenew) ranges from 0.68 to 0.78. The instrumental variable estimations are all significant at the five percent level or less and the nonlinear estimations are significant at about the thirty percent level. Though not conclusive these results provide some evidence that the incidence of impact fees on new homes in a system of communities is positive.

Table 3.3: Reformulated Model Results

	pvestrtax	new	rfee	rfee new	avgrfee
IV Model	**-1.20**	**1186.78**	**3.95**	**0.68**	**45.96**
	0.34	*0.80*	*0.23*	*0.03*	*0.46*
NL Model	**-0.26**	**880.46**	**3.04**	**0.72**	**22.66**
	0.24	*0.86*	*0.55*	*0.31*	*0.79*

3.6 Chapter Summary

This chapter presents an empirical analysis of the incidence fees in a system of communities. The models developed in section 3.4 tests the hypothesis that more than simple tax incidence is at work by including impact fee and community interaction terms to measure the effect of impact fees in specific communities.

Almost all coefficients on these terms are greater than one in absolute value and the negative coefficients are mostly significant at conventional levels. This provides some evidence that other factors besides tax incidence may be at work. While these results are not conclusive, the negative and significant coefficients on the impact fee variable would not be expected if just tax incidence were occurring. The models developed in section 3.5 investigate the overall incidence of impact fees in a system of communities. These models indicate that in a system of communities the overall incidence of impact fees does not appear to be significantly different from zero. This includes the effect of neighboring communities' impact fees. However, the coefficients on the impact fee variable interacted with newness provide some evidence that there is a positive incidence on new homes in this data set.

Chapter 4

Price Indices, Impact Fees, and Incidence

4.1 Introduction

This chapter attempts to determine if development impact fees have a significant effect on home prices by using the method developed by Sieg, Smith, Banzhaf, and Walsh (2001). Their method develops a set of housing price indices and investigates whether these indices are positively related to public goods, amenities, and community income. According to locational equilibrium models, communities with higher levels of all the attributes listed above should also have higher housing prices. This chapter hypothesizes that impact fees may be considered an amenity or public good and if this is true, communities with higher impact fees should also have higher price levels for homes. The presence of an impact fee in a community may signal the willingness of that community to maintain the level of public goods in the face of ongoing development. This may be viewed positively by both new and existing home buyers because it provides some insurance against future tax increases due to growth and the deterioration of the quality of congestible public goods. In the extreme, the fee may also be viewed as a growth control (Skidmore and Peddle, 1998). Outside of the view proposed by Sieg, Smith, Banzhaf, and Walsh, impact fees may have a positive incidence on new homes and in a market where both new and old homes are sold, the increase in the price of new homes will have a general

effect on the entire price level of a community. Given this framework one expects that impact fees and price indices should be positively and significantly related.

4.2 Methodology

The first step in this research is to estimate price indices for each community in the data set. Sieg, Smith, Banzhaf, and Walsh show that price indices can be estimated from hedonic models of housing prices with multiplicative form. Dummy variables can be used to indicate the individual communities and the antilog of the coefficient of the dummy variable will yield an individual price index. The model is estimated as shown below.

$$(1)\qquad SalePrice = A\prod_{i=1}^{n} X_i^{\beta_i} e^{\sum_{j=1}^{k}\sigma_j D_j} e^{\sum_{q=1}^{r}\lambda_q M_q}$$

Here $\boldsymbol{X}$ is a vector of continuous housing characteristics, $\boldsymbol{D}$, is a vector of dummy variables indicating binary housing characteristics, and $\boldsymbol{M}$ is a vector of dummy variables indicating the community. This model can be easily estimated by converting it to the double logarithmic form and the price indices, $\lambda_q s$, can be recovered by taking the antilog of the coefficients of the dummy variables. The model is estimated as shown below.

$$(2)\qquad \ln(SalePrice) = \ln(A) + \sum_{i=1}^{n}\beta_i \ln X_i + \sum_{j=1}^{k}\sigma_i D_j + \sum_{q=1}^{r}\lambda_q M_q$$

The data set from Chapter 3 is used in this estimation. Since the data set includes 15 communities with observations spanning 6 years, each year and community pair can be considered a community. This leads to a total of 90 communities in the data set. Each community and year pair effectively identifies one

price index. A data summary for each community is listed in Appendix E. Once the price indices are recovered they are regressed on the impact fee. Depending on the model, the price indices may also be regressed on either a time trend or year indicators.

4.3 First Stage Estimation

Two variants of the model are estimated to recover price indices. Because there is no housing price index for the Colorado Springs area the first variant of the model is estimated using nominal values of housing prices in the first stage regression of equation (2). Once the nominal price indices are recovered, the second stage of the estimation uses either a time trend or year indicators to control for inflation. The second variant of the model accounts for inflation by using the real sale price of housing to estimate real price indices in equation (2). The real sale price of housing is constructed using the Denver-Boulder-Greeley housing index for the primary residence of owner occupied housing. While the Denver-Boulder-Greeley housing market may not be an accurate representation of the Colorado Springs market, indices constructed with these real prices are used for comparison to the method that controls for inflation using a time trend or year indicators described in equation (3). The second stage regresses the real price index on the real impact fee for the community. Within each variant of the model, the full sample is used and then the sample is segmented into new homes and existing (old) homes. This yields a total of six regressions and allows for comparison of the coefficients across estimation techniques and between new and existing housing.

Results for the first stage regressions are listed in Table 1. All estimations yield reasonable values for the coefficients on the housing characteristics with the exception of the coefficient on baths and new homes. Both of these coefficients are not of the expected sign. R^2 all exceed eighty percent and all other explanatory variables are significant and of the expected sign. It is interesting to note that the models yield the same coefficients on the housing characteristics whether the nominal or real sale price was used. This is to be expected due to the nature of converting from nominal to real values. The model results for the primary variables are listed in Table 4.1.

The price indices for the communities differ depending on whether nominal or real values were used. As expected, price indices differed between models and the average index using real values is lower than that using nominal values. Table 4.2 displays summary measures for the price indices recovered from the six estimations.

Table 4.1: First Stage Model Results for Primary Variables*

Variable	Nominal Sale Price (all homes)	Real Sale Price (all homes)	Nominal Sale Price (new homes only)	Real Sale Price (new homes only)	Nominal Sale Price (old homes only)	Real Sale Price (old homes only)
loglot	**0.141**	**0.141**	**0.108**	**0.108**	**0.151**	**0.151**
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
logfsqft	**0.468**	**0.468**	**0.537**	**0.537**	**0.453**	**0.453**
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
logufsqft	**0.015**	**0.015**	**0.028**	**0.028**	**0.013**	**0.013**
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
logbaths	**-0.013**	**-0.013**	**-0.073**	**-0.073**	**0.007**	**0.007**
	0.021	*0.021*	*0.000*	*0.000*	*0.263*	*0.263*
loggararea	**0.032**	**0.032**	**0.083**	**0.083**	**0.024**	**0.024**
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
logage	**-0.085**	**-0.085**			**-0.089**	**-0.089**
	0.000	*0.000*			*0.000*	*0.000*
ranch	**-0.008**	**-0.008**	**0.001**	**0.001**	**-0.010**	**-0.010**
	0.013	*0.013*	*0.883*	*0.883*	*0.003*	*0.003*
otherstyle	**-0.036**	**-0.036**	**-0.030**	**-0.030**	**-0.034**	**-0.034**
	0.000	*0.000*	*0.002*	*0.002*	*0.000*	*0.000*
new	**-0.080**	**-0.080**				
	0.000	*0.000*				
R^2	**0.865**	**0.855**	**0.805**	**0.789**	**0.880**	**0.868**
Observations	**12302**	**12302**	**3378**	**3378**	**8924**	**8924**

* Probability values are listed below the coefficient.

Table 4.2: Summary of Price Indices

	Price Index Using Nominal Sale Price (all homes)	Price Index Using Real Sale Price (all homes)	Price Index Using Nominal Sale Price (new homes only)	Price Index Using Real Sale Price (new homes only)	Price Index Using Nominal Sale Price (old homes only)	Price Index Using Real Sale Price (old homes only)
Mean	1.078	0.934	1.057	0.922	1.080	0.936
Std. Dev.	0.160	0.112	0.174	0.126	0.161	0.111
Min	0.625	0.586	0.601	0.563	0.665	0.624
Max	1.570	1.300	1.557	1.318	1.573	1.242

4.4 Second Stage Estimation

Once the price indices were recovered a series of regressions were conducted to determine if housing prices responded to the impact fee. The first set of regressions uses all the available data and the nominal price indices. The price indices are regressed against the nominal impact fee, a community variable, and either a time trend or year indicators. The community variable controls for public goods and amenity effects and the time trend or year indicators account for inflation in the data. The second stage of the regression with time dummies is illustrated in equation (3). Here λ is the nominal price index and T is a time dummy variable and C is a community dummy variable.

$$(3) \qquad \lambda = \alpha \; nominalfee + \sum_{i=1}^{n} \delta_i T_j + \sum_{i=1}^{n} \theta_i C_j .$$

Both of the nominal regressions yield a positive coefficient for the nominal impact fee. In fact the coefficients are almost identical regardless of whether a time trend or year indicators are used. The time trend and all of the year indicators are positive and significant as was expected since this data did not account for inflation. Most of the point estimates for the coefficients on the community dummy variables are negative in relation to the base community of Colorado Springs and the coefficients have varying levels of significance. The one community that has a positive and significant coefficient (peregrine) is situated in a scenic location by the mountains and this feature may account for a higher price in relation to the base community.

The estimation using real prices and real impact fees is a good point of comparison to the nominal regressions. The magnitude of the coefficient on impact fees is somewhat larger than in the nominal regressions, however it is still highly insignificant. When trend or year variables are added they turn out to be insignificant. This was expected and seems to indicate that the Denver-Boulder-Greeley housing index is adequately adjusting for housing appreciation in the El Paso County sample of homes. However, since the nominal regressions explicitly control for market effects which may be different from the Denver-Boulder-Greeley market the nominal regressions should be considered more precise. All estimations have high explanatory power as indicated by R^2 of 86 percent or higher. It appears that the community variables are explaining most of the variation in the price indices. The results of these regressions are presented in Table 4.3.

After estimating the effect of impact fees on the price indices for the entire data set, the sample was segmented into new and existing homes to see if the results differed for these two categories. The nominal price indices were regressed on the nominal impact fee and either a time trend or year indicators to again control for inflation. The results did not differ much from the full sample. Again the coefficient on the impact fee is insignificant and no conclusion can be drawn concerning the effect of impact fees on the community price indices. Again, the regressions do explain much of the variation in the price indices and the individual community variables account for much of the variation. The results of these regressions are listed in Table 4.4 and the full sample results are also lists as a point of comparison.

Table 4.3: Model Results for All Homes*

Variable	Nominal Price Index (with trend)	Nominal Price Index (with year indicators)	Real Price Index	Real Price Index (with trend)	Real Price Index (with year indicators)
nfee	**4.81E-06**	**4.99E-06**			
	0.449	*0.453*			
rfee			**5.86E-06**	**6.01E-06**	**7.01E-06**
			0.248	*0.240*	*0.204*
trend	**0.056**			**0.001**	
	0.000			*0.583*	
d95		**0.054**			**-0.009**
		0.002			*0.566*
d96		**0.122**			**0.002**
		0.000			*0.915*
d97		**0.156**			**-0.003**
		0.000			*0.854*
d98		**0.213**			**-0.002**
		0.000			*0.916*
d99		**0.290**			**0.006**
		0.000			*0.679*
Academy	**-0.085**	**-0.086**	**-0.089**	**-0.090**	**-0.096**
	0.028	*0.031*	*0.022*	*0.021*	*0.020*
Donala	**0.016**	**0.015**	**-0.001**	**-0.002**	**-0.008**
	0.679	*0.703*	*0.972*	*0.954*	*0.841*
Monument	**-0.119**	**-0.120**	**-0.129**	**-0.131**	**-0.140**
	0.023	*0.026*	*0.013*	*0.013*	*0.013*
Palmer1	**-0.069**	**-0.070**	**-0.082**	**-0.083**	**-0.091**
	0.135	*0.142*	*0.072*	*0.070*	*0.063*
Palmer2	**-0.066**	**-0.066**	**-0.065**	**-0.066**	**-0.070**
	0.040	*0.043*	*0.034*	*0.033*	*0.032*
Woodmoor	**-0.005**	**-0.006**	**-0.024**	**-0.025**	**-0.033**
	0.911	*0.895*	*0.610*	*0.595*	*0.510*
Arrowwood	**-0.065**	**-0.064**	**-0.045**	**-0.044**	**-0.038**
	0.084	*0.096*	*0.225*	*0.236*	*0.328*
Blackforest	**-0.193**	**-0.192**	**-0.155**	**-0.154**	**-0.149**
	0.000	*0.000*	*0.000*	*0.000*	*0.000*
Falcon	**-0.247**	**-0.246**	**-0.204**	**-0.203**	**-0.197**
	0.000	*0.000*	*0.000*	*0.000*	*0.000*
Dwfire	**-0.047**	**-0.046**	**-0.027**	**-0.026**	**-0.020**
	0.204	*0.224*	*0.469*	*0.485*	*0.605*
Nofire	**-0.198**	**-0.198**	**-0.159**	**-0.159**	**-0.153**
	0.000	*0.000*	*0.000*	*0.000*	*0.000*
Briargate	**-0.035**	**-0.035**	**-0.030**	**-0.030**	**-0.030**
	0.155	*0.156*	*0.205*	*0.207*	*0.217*
Norwood	**-0.312**	**-0.032**	**-0.028**	**-0.028**	**-0.028**
	0.197	*0.198*	*0.231*	*0.233*	*0.243*
Peregrine	**0.251**	**0.251**	**0.221**	**0.221**	**0.221**
	0.000	*0.000*	*0.000*	*0.000*	*0.000*
constant	**0.916**	**0.973**	**0.952**	**0.946**	**0.946**
	0.000	*0.000*	*0.000*	*0.000*	*0.000*
R2	**0.930**	**0.929**	**0.871**	**0.870**	**0.863**
Observations	**90**	**90**	**90**	**90**	**90**

* Probability values are listed below the coefficient.

Table 4.4: New Homes and Existing Homes*

Variable	Nominal Price Index, All Homes (with trend)	Nominal Price Index, All Homes (with year indicators)	Nominal Price Index, New Homes (with trend)	Nominal Price Index, New Homes (with year indicators)	Nominal Price Index, Existing Homes (with trend)	Nominal Price Index, Existing Homes (with year indicators)
nfee	**4.81E-06**	**4.99E-06**	**1.69E-06**	**3.76E-07**	**5.45E-06**	**5.20E-06**
	0.449	*0.453*	*0.892*	*0.977*	*0.376*	*0.422*
trend	**0.056**		**0.054**		**0.057**	
	0.000		*0.000*		*0.000*	
d95		**0.054**		**0.053**		**0.056**
		0.002		*0.103*		*0.001*
d96		**0.122**		**0.095**		**0.126**
		0.000		*0.006*		*0.000*
d97		**0.156**		**0.128**		**0.165**
		0.000		*0.000*		*0.000*
d98		**0.213**		**0.216**		**0.219**
		0.000		*0.000*		*0.000*
d99		**0.290**		**0.271**		**0.295**
		0.000		*0.000*		*0.000*
Academy	**-0.085**	**-0.086**	**-0.129**	**-0.137**	**-0.084**	**-0.083**
	0.028	*0.031*	*0.108*	*0.103*	*0.025*	*0.033*
Donala	**0.016**	**0.015**	**0.025**	**0.016**	**-0.002**	**0.000**
	0.679	*0.703*	*0.735*	*0.840*	*0.966*	*0.991*
Monument	**-0.119**	**-0.120**	**-0.127**	**-0.142**	**-0.139**	**-0.137**
	0.023	*0.026*	*0.207*	*0.181*	*0.006*	*0.010*
Palmer1	**-0.069**	**-0.070**	**-0.077**	**-0.090**	**-0.072**	**-0.070**
	0.135	*0.142*	*0.386*	*0.338*	*0.107*	*0.129*
Palmer2	**-0.066**	**-0.066**	**-0.131**	**-0.135**	**-0.068**	**-0.068**
	0.040	*0.043*	*0.037*	*0.037*	*0.028*	*0.034*
Woodmoor	**-0.005**	**-0.006**	**-0.004**	**-0.017**	**-0.012**	**-0.011**
	0.911	*0.895*	*0.968*	*0.863*	*0.782*	*0.816*
Arrowwood	**-0.065**	**-0.064**	**-0.066**	**-0.057**	**-0.086**	**-0.087**
	0.084	*0.096*	*0.364*	*0.453*	*0.019*	*0.022*
Blackforest	**-0.193**	**-0.192**	**-0.198**	**-0.189**	**-0.208**	**-0.210**
	0.000	*0.000*	*0.007*	*0.014*	*0.000*	*0.000*
Falcon	**-0.247**	**-0.246**	**-0.327**	**-0.316**	**-0.246**	**-0.247**
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
Dwfire	**-0.047**	**-0.046**	**-0.089**	**-0.080**	**-0.068**	**-0.070**
	0.204	*0.224*	*0.221*	*0.292*	*0.059*	*0.064*
Nofire	**-0.198**	**-0.198**	**-0.273**	**-0.264**	**-0.195**	**-0.196**
	0.000	*0.000*	*0.000*	*0.001*	*0.000*	*0.000*
Briargate	**-0.035**	**-0.035**	**-0.084**	**-0.084**	**-0.028**	**-0.028**
	0.155	*0.156*	*0.079*	*0.084*	*0.236*	*0.239*
Norwood	**-0.312**	**-0.032**	**-0.102**	**-0.105**	**-0.029**	**-0.029**
	0.197	*0.198*	*0.083*	*0.081*	*0.221*	*0.224*
Peregrine	**0.251**	**0.251**	**0.215**	**0.215**	**0.238**	**0.238**
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
constant	**0.916**	**0.973**	**0.969**	**1.021**	**0.918**	**0.975**
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
R2	**0.930**	**0.929**	**0.780**	**0.772**	**0.935**	**0.934**
Observations	**90**	**90**	**83**	**83**	**90**	**90**

* Probability values are listed below the coefficient.

One reason why the coefficient on the impact fee may not be significant in these estimations is because the impact fee and community are highly collinear. In communities that do not charge an impact fee the impact fee does not vary and the community and fee identify the same characteristics. In communities that do charge a fee, the level of the fee may change erratically. Some communities may not change the fee for a significant amount of time or the fee may be adjusted annually. Infrequent adjustment of the fee also leads to collinearity with the community variable.

Because the impact fee and community variables are highly collinear, the coefficient of the impact fee cannot be estimated precisely and collinearity leads to large standard errors and insignificant t-statistics. While the coefficient on the impact fee is still BLUE, this does not help in the task at hand. One of the simplest remedies for multicollinearity is to drop the collinear variable and re-estimate the model. However, one must realize that this procedure leads to specification bias (Gujarati 2003, p. 365). If the community variables are dropped in attempt to understand the relationship between the impact fee and the price index, the new coefficient on the impact fee may be picking up the amenity effects of the community as well as the influence of the impact fee on the price index. Despite these problems, the model was re-estimated by dropping the community variables. Table 4.5 displays the results for the full sample. Columns one and two replicate the results for the nominal regressions with the community variables as a point of comparison.

Table 4.5: Model Results for All Homes Excluding Community Variables*

Variable	Nominal Price Index, With Community Variables (with trend)	Nominal Price Index, With Community Variables (with year indicator)	Nominal Price Index, No Community Variables (with trend)	Nominal Price Index, No Community Variables (with year indicators)
nfee	**4.81E-06**	**4.99E-06**	**1.23E-05**	**1.23E-05**
	0.449	*0.453*	*0.000*	*0.000*
trend	**0.056**		**0.055**	
	0.000		*0.000*	
d95		**0.054**		**0.052**
		0.002		*0.238*
d96		**0.122**		**0.119**
		0.000		*0.008*
d97		**0.156**		**0.152**
		0.000		*0.001*
d98		**0.213**		**0.209**
		0.000		*0.000*
d99		**0.290**		**0.285**
		0.000		*0.000*
constant	**0.916**	**0.973**	**0.822**	**0.878**
	0.000	*0.000*	*0.000*	*0.000*
R2	**0.930**	**0.929**	**0.477**	**0.455**
Observations	**90**	**90**	**90**	**90**

* Probability values are listed below the coefficient.

As can be seen by comparing the estimations with community variables to the ones without, the coefficient on the impact fee is now highly significant. Comparing R^2 for like models indicates that the community variables do contribute a lot to the explanatory power of the mode. If, one is willing to accept this regression as evidence that the impact fee is significant in the full model, then the coefficients for the impact fee in tables 4.3 and 4.4 shed some light on the effect of impact fees on home prices.

In order to interpret the coefficient on the impact fee in an easy to understand format, it is necessary to use the price of a standardized house across communities. This requires the price index to be scaled by a quantity index. Using the fact that price index * quantity index = house value, the regressions of the price index on the impact fee can be scaled to recover a more meaningful coefficient for the impact fee. According to Gugarati (2003) the scaling factor is simply the weight applied to the price index (in this case the weight is the quantity index) divided by the weight applied to the impact fee which is one. Therefore a coefficient that relates the change in house price to the change in impact fee for a standardized house can be constructed as follows:

$$(4) \qquad B^{*} = \left(\frac{w_1}{w_2}\right) B$$

Where B is the estimated coefficient on the impact fee from the nominal regression, w_1 is the weight applied to the price index (the quantity index), and w_2 is set equal to one.

The quantity index, w_1, can be recovered from the first stage of the regression by predicting the value of a standardized house in the base district where the price index is equal to one. A standardized house was considered to have the average characteristics of the entire data set and the first stage regression employing nominal house values was used. A typical house has three bedrooms and lot size was set equal to 21,000 square feet (approximately one half acre). The finished square footage was 2,500 with an unfinished square footage of 550 square feet. The area of the garage was 550 square feet and the average age was seven. The quantity index for the

average existing two story house was \$186,591. Substituting this value for w_1 in equation (4), using a w_2 value of one, and then multiplying by the coefficient of the impact fee from the regression of the nominal price index with all homes and year indicators in Table 4.3 (4.99e-06) yields an easy to understand B^* of 0.93. This implies that a one dollar increase in the impact fee results in a \$0.93 increase in the housing price. An estimation weighting the price index by this quantity index confirms the results and has the same t statistics and p values found in the original estimation. Homes with a lower quantity index will result in a lower increase in house value for a one dollar change in the impact fee and homes with a higher quantity index (more square feet, lot size, etc.) will have a higher change in price due to a one dollar increase in the impact fee.

4.5 Adding the Tax Variable

Theory implies that the model is not complete unless the model includes property tax capitalization. In order to measure the effect of the property tax on the price of homes, the tax rate for each community was added to the regression of the nominal price index on the nominal impact fee with year dummies and community variables. The coefficient on the impact fee was not seriously affected by the addition of the tax variable (1.38e-6 versus 4.99e-6 in the original regression without the tax). The coefficient on the property tax was negative as expected, but insignificant at conventional levels.

There is a serious flaw to this approach. Regressing the tax rate on the price index does not account for the quantity of housing. Tax rates may change, but

assessed housing values may also change so that the tax payment may increase or decrease with an increase in the tax rate. To account for this problem an attempt at constructing an index of tax payments was employed. The idea is to take a group of houses in each community and follow their tax payments over time to construct the tax index. This index would account for the quantity of housing because it would use the same group of houses in each period. Equation (5) illustrates the method.

$$(5) \qquad Index_{jt} = \frac{\sum_{i=1}^{n} Taxpament_{it}}{\sum_{i=1}^{n} Taxpament_{i1}}$$

The index for community j at period t is defined as the sum of the tax payments on all homes i at period t divided by the sum of all tax payments on homes i during period 1. This method turned out to be impractical since only three of six years in the data set had recorded tax payments and this information was also incomplete. Furthermore, while this method can construct an index to follow tax payments in a given community over time, it does not allow for a consistent index across communities because the housing characteristics vary across communities.

To control for quantity it was decided to use a method similar to that used in Chapter 3 and also employed to in this chapter to interpret the coefficient on the impact fee. First, the price of a standardized home in each district was predicted from the first stage regression of nominal home prices on housing characteristics. These characteristics were listed above. Next the present value of the tax payment was calculated to serve as the tax variable. Finally a non linear regression was conducted to estimate the coefficient on the tax payment and on the impact fee. The second

regression employs dummy variables for time and community. The method is illustrated in equation (6).

$$NomHousePrice = \beta_1 + \beta_2 taxrate\left(\frac{NomHousePrice}{DiscountRate}\right) + \beta_3 NomImpactFee + \sum_{i=1}^{n}\delta_i T_j + \sum_{i=1}^{n}\theta_i C_j \tag{6}$$

Equivalently:

$$NomPriceIndex * QuantityIndex = \beta_1 + \beta_2 taxrate\left(\frac{NomPriceIndex * QuantityIndex}{DiscountRate}\right) + \beta_3 NomImpactFee + \sum_{i=1}^{n}\delta_i T_j + \sum_{i=1}^{n}\theta_i C_j \tag{7}$$

The quantity index is the value of a standardized home in the base community and is constant across communities and the price index varies across communities. Using a discount rate of 0.03 the non linear regression becomes:

$$NomHousePrice = \left(\frac{0.03}{0.03 - \beta_2 taxrate}\right)\left(\beta_1 + \beta_3 NomImpactFee + \sum_{i=1}^{n}\delta_i T_j + \sum_{i=1}^{n}\theta_i C_j\right). \tag{8}$$

The results of this regression are easy to interpret. The coefficient on the impact fee represents the change in house price for a one dollar change in the impact fee and the coefficient on the tax variable, β_2, represents the change in house value for a one dollar change in the tax payment. The results of this model for the impact fee and tax payment are listed in Table 4.6 below.

Table 4.6: Nonlinear Regression, Including Tax Payment*

Variable	Nonlinear Regression (with time and community dummies)
nfee	**0.767**
	0.577
Tax payment	**-0.132**
	0.727
R2	**0.999**
Observations	**90**

* Probability values are listed below the coefficient.

The R^2 is greater than 0.99. The coefficient on the impact fee is slightly less than the model that does not include the tax payment and it is still insignificant. However, this model still suffers from multicollinearity with the community variables (not listed in the table). As previously discussed, the coefficient is expected to have large standard errors and insignificant t-statistics even if this variable does have explanatory power and the coefficient is still BLUE. A one dollar increase in the impact fee is therefore expected to cause a $0.77 increase in home value. The coefficient on the tax payment is negative as expected, but it is also insignificant. However, this final model should include property tax capitalization to be correctly specified. The property tax coefficient may be insignificant because is also highly correlated to the year and community variables. However, significance of this variable is not of primary interest.

4.6 Conclusion

The above estimations provide evidence that higher impact fees are associated with higher community price indices or the price of a standardized home in a community. This supports the notion that there is either a positive incidence associated with impact fees or that fees are perceived as an amenity that increases home value. These results are not as strong as was hoped, but in conjunction with the results of Chapter 3, they help build a case for the positive incidence of impact fees.

Chapter 5

Comments and Conclusion

This dissertation extends previous research on the incidence of development impact fees by explicitly modeling fees in a system of communities. A budget balance condition, as well as property tax capitalization are included. The model confirms that an impact fee, when adopted in all communities, is a Pareto-efficient when contrasted with property tax finance. Under a property tax only, the model reveals that when the number of new residents in the system increases, tax payments for existing residents increase and consumption decreases. Growth for resident-renters is welfare reducing when the only method of infrastructure finance is the property tax. When only one community adopts impact fees, the incidence on land may be either positive or negative depending on the level of the fee. When both communities adopt impact fees the incidence of the fee is positive. More interesting are the welfare implications associated with the fee. This is because fees are welfare enhancing for existing residents of the community that adopts the fee. If one community adopts fees and another community does not, the fee is welfare enhancing for existing resident-renters of the community that adopts the fee. However, the existing resident-renters of the community that does not adopt the fee experience a drop in their welfare because more new residents locate in their community and they subsidize their infrastructure cost. This result holds when existing residents are assumed to own their plot of land. Given that growth under a property tax regime is

welfare reducing and impact fees are welfare enhancing for existing residents, there is a strong incentive to adopt impact fees when there is growth or neighboring communities adopt fees.

The empirical model of Chapter 3 supports the notion that impact fees may decrease price and the model of Chapter 4 shows that the general incidence of impact fees in a system of communities that impose uneven impact fees can be positive. The addition of a variable in the reformulated model of Chapter 3 to measure the effect of other communities' impact fee on a given community is inconclusive. This may be because the use of the average impact fee of other communities is not adequately measuring the true effect other communities have on their neighbors. Further research might be designed to construct a weighted average of other communities' impact fees based on distance from the given community. This may more accurately reflect a given community's effect on its immediate neighbors versus using a non-weighted average.

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Appendix A: Program to Compute Equilibrium Solutions and Comparative Statics in Chapter 2

```
Clear[x11, x12, x21, x22, a11, a12, a21, a22, n11, n12, n21, n22, N2, N1, P1, P2, t1, t2, A1, A2, L, solution, z1, z2, g1,
   g2, jacob, jacob1, detjacob, derivsys, derivsyswrtI1, I1, I2, dP1dI1, b, a, d, counter1, counter2, counter3, counter4,
   initial, stop, step, row, mat1, mat2, answer1, answer2, place, T1, T2, f1, f2, f3, f4, f5, f6, f7, f8, f9, f10, f11, f12,
   f13, f14, f15, f16, f17, f18, f19, f20, f21];

initial = 0;
stop = 15000;
step = 100;

(*Create matrix to hold optimal values with room for column headings*)
mat1 = Array[answer1, {stop/step + 2, 13}] // MatrixForm;

(*Create matrix to hold utility for type11, type 12, type21, type 22 with room for column headings*)
mat2 = Array[answer2, {stop/step + 2, 5}] // MatrixForm;

(*Create matrix to hold comparitive statics with column headings*)
mat3 = Array[answer3, {stop/step + 2, 13}] // MatrixForm;

(*sets column headings for the matrix of optimal values*)
answer1[1, 1] = "I1";
answer1[1, 2] = "x11";
answer1[1, 3] = "x12";
answer1[1, 4] = "x21";
answer1[1, 5] = "x22";
answer1[1, 6] = "a21";
answer1[1, 7] = "a22";
answer1[1, 8] = "n21";
answer1[1, 9] = "n22";
answer1[1, 10] = "t2";
answer1[1, 11] = "t1";
answer1[1, 12] = "P1";
answer1[1, 13] = "P2";

(*sets column headings for matrix of utility values*)
answer2[1, 1] = "I1";
answer2[1, 2] = "u11";
answer2[1, 3] = "u12";
answer2[1, 4] = "u21";
answer2[1, 5] = "u22";
```

```
row = 1;
For[counter1 = 0, counter1 <= stop, counter1 = counter1 + step,
  {Clear[x11, x12, x21, x22, a11, a12, a21, a22, n11, n12, n21, n22, N2, N1, P1, P2, t1, t2, A1, A2,
     L, solution, z1, z2, g1, g2, jacob, jacob1, detjacob, derivsys, derivsyswrtI1, I1, I2, dP1dI1, b,
     a, d, counter2, counter3, counter4, place, T1, T2, f1, f2, f3, f4, f5, f6, f7, f8, f9, f10, f11, f12,
     f13, f14, f15, f16, f17, f18, f19, f20, f21],

(*Sets all exogenous variable except I1*)
T1 = 0,
T2 = 0,
L = 100000,
I1,
I2 = 0,
z1 = 15000,
z2 = 15000,
g1 = 15000,
g2 = 15000,
A1 = 2560,
A2 = 2560,
a11 = 0.25,
a12 = 0.25,
n11 = 5120,
n12 = 5120,
N2 = 10240,
a = 0.01,
b = 0.85,
d = 0.03,

(*Establish general form of matricies to solve for comparitive statics. The equations of the model and matricies follow.*)

(*Individual budget constraints*)
f1 = L + T1 - x11 - P1 * (d + t1) * a11,
f2 = L + T2 - x12 - P2 * (d + t2) * a12,
f3 = L - x21 - P1 * (d + t1) * a21 - I1,
f4 = L - x22 - P2 * (d + t2) * a22 - I2,

(*Uiltiy conditions and first derivative equations*)
f14 = g1^a * x21^b * a21^(1 - b),
f15 = g2^a * x22^b * a22^(1 - b),
f16 = ∂x21 f14,
f17 = ∂a21 f14,
f18 = ∂x22 f15,
f19 = ∂a22 f15,
```

```
(*The FOC from the maximization problem for type 2s in community 1 follows*)
f5 = (f17/f16) - P1*(d+t1),

(*The FOC from the maximizaiton problem for type 2s in community 2 follows*)
f6 = (f19/f18) - P2*(d+t2),

(*The community budget constraints follow*)
f7 = n11*P1*t1*a11+n21*P1*t1*a21+n21*I1-n21*z1,
f8 = n12*P2*t2*a12+n22*P2*t2*a22+n22*I2-n22*z2,
(*The equal utility constraint follows:*)
f9 = f14-f15,

(*The population constraint for type 2s follows:*)
f10 = n21+n22-N2,

(*Land constraints follow:*)
f11 = A1-n11*a11-n21*a21,
f12 = A2-n12*a12-n22*a22,

(*Not system equations, but equations to evaluate utilties of type 1s*)
f20 = g1^a*x11^b*a11^(1-b),
f21 = g2^a*x12^b*a12^(1-b),

(*The system of equations is linearized with by employing the implicit function theorm The
   jacobian for the linearized equation follows. This is the coefficient matrix on the linearized equations*)
```

$$\text{jacob}=\begin{pmatrix}
\partial_{x11}\text{f1} & \partial_{x12}\text{f1} & \partial_{x21}\text{f1} & \partial_{x22}\text{f1} & \partial_{a21}\text{f1} & \partial_{a22}\text{f1} & \partial_{t1}\text{f1} & \partial_{t2}\text{f1} & \partial_{P1}\text{f1} & \partial_{P2}\text{f1} & \partial_{n21}\text{f1} & \partial_{n22}\text{f1} \\
\partial_{x11}\text{f2} & \partial_{x12}\text{f2} & \partial_{x21}\text{f2} & \partial_{x22}\text{f2} & \partial_{a21}\text{f2} & \partial_{a22}\text{f2} & \partial_{t1}\text{f2} & \partial_{t2}\text{f2} & \partial_{P1}\text{f2} & \partial_{P2}\text{f2} & \partial_{n21}\text{f2} & \partial_{n22}\text{f2} \\
\partial_{x11}\text{f3} & \partial_{x12}\text{f3} & \partial_{x21}\text{f3} & \partial_{x22}\text{f3} & \partial_{a21}\text{f3} & \partial_{a22}\text{f3} & \partial_{t1}\text{f3} & \partial_{t2}\text{f3} & \partial_{P1}\text{f3} & \partial_{P2}\text{f3} & \partial_{n21}\text{f3} & \partial_{n22}\text{f3} \\
\partial_{x11}\text{f4} & \partial_{x12}\text{f4} & \partial_{x21}\text{f4} & \partial_{x22}\text{f4} & \partial_{a21}\text{f4} & \partial_{a22}\text{f4} & \partial_{t1}\text{f4} & \partial_{t2}\text{f4} & \partial_{P1}\text{f4} & \partial_{P2}\text{f4} & \partial_{n21}\text{f4} & \partial_{n22}\text{f4} \\
\partial_{x11}\text{f5} & \partial_{x12}\text{f5} & \partial_{x21}\text{f5} & \partial_{x22}\text{f5} & \partial_{a21}\text{f5} & \partial_{a22}\text{f5} & \partial_{t1}\text{f5} & \partial_{t2}\text{f5} & \partial_{P1}\text{f5} & \partial_{P2}\text{f5} & \partial_{n21}\text{f5} & \partial_{n22}\text{f5} \\
\partial_{x11}\text{f6} & \partial_{x12}\text{f6} & \partial_{x21}\text{f6} & \partial_{x22}\text{f6} & \partial_{a21}\text{f6} & \partial_{a22}\text{f6} & \partial_{t1}\text{f6} & \partial_{t2}\text{f6} & \partial_{P1}\text{f6} & \partial_{P2}\text{f6} & \partial_{n21}\text{f6} & \partial_{n22}\text{f6} \\
\partial_{x11}\text{f7} & \partial_{x12}\text{f7} & \partial_{x21}\text{f7} & \partial_{x22}\text{f7} & \partial_{a21}\text{f7} & \partial_{a22}\text{f7} & \partial_{t1}\text{f7} & \partial_{t2}\text{f7} & \partial_{P1}\text{f7} & \partial_{P2}\text{f7} & \partial_{n21}\text{f7} & \partial_{n22}\text{f7} \\
\partial_{x11}\text{f8} & \partial_{x12}\text{f8} & \partial_{x21}\text{f8} & \partial_{x22}\text{f8} & \partial_{a21}\text{f8} & \partial_{a22}\text{f8} & \partial_{t1}\text{f8} & \partial_{t2}\text{f8} & \partial_{P1}\text{f8} & \partial_{P2}\text{f8} & \partial_{n21}\text{f8} & \partial_{n22}\text{f8} \\
\partial_{x11}\text{f9} & \partial_{x12}\text{f9} & \partial_{x21}\text{f9} & \partial_{x22}\text{f9} & \partial_{a21}\text{f9} & \partial_{a22}\text{f9} & \partial_{t1}\text{f9} & \partial_{t2}\text{f9} & \partial_{P1}\text{f9} & \partial_{P2}\text{f9} & \partial_{n21}\text{f9} & \partial_{n22}\text{f9} \\
\partial_{x11}\text{f10} & \partial_{x12}\text{f10} & \partial_{x21}\text{f10} & \partial_{x22}\text{f10} & \partial_{a21}\text{f10} & \partial_{a22}\text{f10} & \partial_{t1}\text{f10} & \partial_{t2}\text{f10} & \partial_{P1}\text{f10} & \partial_{P2}\text{f10} & \partial_{n21}\text{f10} & \partial_{n22}\text{f10} \\
\partial_{x11}\text{f11} & \partial_{x12}\text{f11} & \partial_{x21}\text{f11} & \partial_{x22}\text{f11} & \partial_{a21}\text{f11} & \partial_{a22}\text{f11} & \partial_{t1}\text{f11} & \partial_{t2}\text{f11} & \partial_{P1}\text{f11} & \partial_{P2}\text{f11} & \partial_{n21}\text{f11} & \partial_{n22}\text{f11} \\
\partial_{x11}\text{f12} & \partial_{x12}\text{f12} & \partial_{x21}\text{f12} & \partial_{x22}\text{f12} & \partial_{a21}\text{f12} & \partial_{a22}\text{f12} & \partial_{t1}\text{f12} & \partial_{t2}\text{f12} & \partial_{P1}\text{f12} & \partial_{P2}\text{f12} & \partial_{n21}\text{f12} & \partial_{n22}\text{f12}
\end{pmatrix}$$

(*The RHS of the linearized system of equations follows:*)

$$\text{derivsyswrtI1} = \left(\begin{array}{|c|} -\partial_{I1}\,f1 \\ -\partial_{I1}\,f2 \\ -\partial_{I1}\,f3 \\ -\partial_{I1}\,f4 \\ -\partial_{I1}\,f5 \\ -\partial_{I1}\,f6 \\ -\partial_{I1}\,f7 \\ -\partial_{I1}\,f8 \\ -\partial_{I1}\,f9 \\ -\partial_{I1}\,f10 \\ -\partial_{I1}\,f11 \\ -\partial_{I1}\,f12 \end{array}\right),$$

(*Solve for optimal solution given exogenous variables.*)

```
(*Set the value of the Impact Fee*)
I1 = counter1 - step,
(*answer[row,1]=I1,*)

(*Put the value of the impact fee in the answer matricies.*)
answer1[row+1, 1] = I1,
answer2[row+1, 1] = I1,
answer3[row+1, 1] = I1,

(*Solve for the optimal values of the endogenous variables given the exogenous variables and
   specified impact fee.*)
place = Solve[{L==x11 + P1 (d+t1) a11, L==x12 + P2(d+t2) a12, L==x21 + P1 (d+t1) a21 + I1,
     L==x22 + P2(d+t2) a22 + I2, n11 P1 t1 a11 + n21 P1 t1 a21 + n21 I1 ==n21 z1,
     n12 P2 t2 a12 + n22 P2 t2 a22 + n22 I2 ==n22 z2, A1 == n11 a11 + n21 a21, A2 ==n12 a12 + n22 a22,
     N2 ==n21 + n22, P2 (d+t2) ==((1 - b) x22) / (b a22), P1 (d+t1) ==((1 - b) x21) / (b a21),
     (g1^a) (x21^b) (a21^(1 - b)) ==(g2^a) (x22^b) (a22^(1 - b)) },
   {x11, x12, x21, x22, a21, a22, n21, n22, t2, P2, t1, P1}],
```

```
(*Explicitly assign values to the endogenous variables from the solution above.*)
x11 = x11 /. place[[1,1]],
x12 = x12 /. place[[1,2]],
x21 = x21 /. place[[1,3]],
x22 = x22 /. place[[1,4]],
a21 = a21 /. place[[1,5]],
a22 = a22 /. place[[1,6]],
n21 = n21 /. place[[1,7]],
n22 = n22 /. place[[1,8]],
t2 = t2 /. place[[1,9]],
t1 = t1 /. place[[1,10]],
P1 = P1 /. place[[1,11]],
P2 = P2 /. place[[1,12]],

(*Put the values for the optimal solution for the endogenous variables, given exogenous variables, in a matrix.*)
For[counter2 = 1, counter2 < 13, counter2++;
        answer1[row+1, counter2] = place[[1,counter2-1]]],

answer1[row+1, 2] = x11,
answer1[row+1, 3] = x12,
answer1[row+1, 4] = x21,
answer1[row+1, 5] = x22,
answer1[row+1, 6] = a21,
answer1[row+1, 7] = a22,
answer1[row+1, 8] = n21,
answer1[row+1, 9] = n22,
answer1[row+1, 10] = t2,
answer1[row+1, 11] = t1,
answer1[row+1, 12] = P1,
answer1[row+1, 13] = P2,

(*Find the utility level for U11, U12, U21, U22, at the given solution and place in a matrix*)
answer2[row+1, 2] = f20,
answer2[row+1, 3] = f21,
answer2[row+1, 4] = f14,
answer2[row+1, 5] = f15,

(*Find the comparitive statics of the problem using the optimal solution found at a given impact fee.*)
jacob1 = Evaluate[jacob],

(*Check that the determinant of the jacobian is non-zero and a solution exists.*)
Det[jacob1],
derivsys = Evaluate[derivsyswrtI1],
```

```
(*Solve for a specific solution for the comparitive statics, given the exogenous variables and impact fee.*)
    solution = LinearSolve[jacob1, derivsys],

    (*Place the comparitive statics in a matrix.*)
    (*For[counter4=1,counter4<13,counter2++;
            answer3[row,counter4]=solution[[counter4-1,1]],*)

    For[counter4 = 1, counter4 < 13, counter4++;
            answer3[row+1, counter4] = solution[[counter4-1,1]],

    row++

    }]

(*Out put of optimal solution given impact fee in mat1*)
mat1

(*Output of utility at given optimal solution in mat2*)
mat2

(*Output of comparitive statics at given optimal solution and impact fee.*)
mat3
```

Appendix B: Formulas for Tax Rates, Prices, and New Residents per Community in Chapter 2

Tax Rates

$$t1 = \frac{d\,I1 - d\,z1}{I1 - 2\,b\,I1 - 2\,W + 2\,b\,W + z1}$$

$$t2 = \frac{d\,I2 - d\,z2}{I2 - 2\,b\,I2 - 2\,W + 2\,b\,W + z2}$$

Prices (in terms of tax rates)

$$P1 = \frac{(I1 - z1)\left(-N2 + \dfrac{A2\,N2\,t2\,(-I1+z1)}{A2\,t2\,(-I1+z1) - \dfrac{A1\left(\frac{g1}{g2}\right)^{\frac{a}{1-b}} t1\,(d+t2)\,(-I1+W)^{\frac{1}{1-b}}\,(-I2+W)^{-\frac{1}{1-b}}\,(I2-z2)}{d+t1}}\right)}{A1\,t1}$$

$$P2 = -\frac{N2\,(-I1 + z1)\,(I2 - z2)}{A2\,t2\,(-I1 + z1) - \dfrac{A1\left(\frac{g1}{g2}\right)^{\frac{a}{1-b}} t1\,(d+t2)\,(-I1+W)^{\frac{1}{1-b}}\,(-I2+W)^{-\frac{1}{1-b}}\,(I2-z2)}{d+t1}}$$

New Residents per Community (in terms of tax rates)

$$n21 = N2 - \frac{A2\,N2\,t2\,(-I1 + z1)}{A2\,t2\,(-I1 + z1) - \dfrac{A1\left(\frac{g1}{g2}\right)^{\frac{a}{1-b}} t1\,(d+t2)\,(-I1+W)^{\frac{1}{1-b}}\,(-I2+W)^{-\frac{1}{1-b}}\,(I2-z2)}{d+t1}}$$

$$n22 = \frac{A2\,N2\,t2\,(-I1 + z1)}{A2\,t2\,(-I1 + z1) - \dfrac{A1\left(\frac{g1}{g2}\right)^{\frac{a}{1-b}} t1\,(d+t2)\,(-I1+W)^{\frac{1}{1-b}}\,(-I2+W)^{-\frac{1}{1-b}}\,(I2-z2)}{d+t1}}$$

Prices (complete expression eliminating tax rates)

$$P1 = -\frac{N2\,(I1 - z1)\,(I1 - 2\,b\,I1 - 2\,W + 2\,b\,W + z1)}{A1\,(d\,I1 - d\,z1)} + \frac{A2\,N2\,(I1 - z1)^2\,(I1 - 2\,b\,I1 - 2\,W + 2\,b\,W + z1)\,(d\,I2 - d\,z2)}{A1\,(d\,I1 - d\,z1)\,(I2 - 2\,b\,I2 - 2\,W + 2\,b\,W + z2)\left(\frac{A2\,(I1-z1)\,(d\,I2-d\,z2)}{I2-2\,b\,I2-2\,W+2\,b\,W+z2} + \frac{A1\left(\frac{g1}{g2}\right)^{\frac{a}{1-b}}(-I1+W)^{\frac{1}{1-b}}(-I2+W)^{-\frac{1}{1-b}}\,(d\,I1-d\,z1)\,(I2-z2)\left(d+\frac{d\,I2-d\,z2}{I2-2\,b\,I2-2\,W+2\,b\,W+z2}\right)}{(I1-2\,b\,I1-2\,W+2\,b\,W+z1)\left(d+\frac{d\,I1-d\,z1}{I1-2\,b\,I1-2\,W+2\,b\,W+z1}\right)}\right)}$$

$$P2 = -\frac{N2\,(I1 - z1)\,(I2 - z2)}{\frac{A2\,(I1-z1)\,(d\,I2-d\,z2)}{I2-2\,b\,I2-2\,W+2\,b\,W+z2} + \frac{A1\left(\frac{g1}{g2}\right)^{\frac{a}{1-b}}(-I1+W)^{\frac{1}{1-b}}(-I2+W)^{-\frac{1}{1-b}}\,(d\,I1-d\,z1)\,(I2-z2)\left(d+\frac{d\,I2-d\,z2}{I2-2\,b\,I2-2\,W+2\,b\,W+z2}\right)}{(I1-2\,b\,I1-2\,W+2\,b\,W+z1)\left(d+\frac{d\,I1-d\,z1}{I1-2\,b\,I1-2\,W+2\,b\,W+z1}\right)}}$$

New Residents per Community (complete expression eliminating tax rates)

$$n21 = N2 - \frac{A2\, N2\, (I1 - z1)\, (d\, I2 - d\, z2)}{(I2 - 2\, b\, I2 - 2\, W + 2\, b\, W + z2) \left(\frac{A2\, (I1-z1)\, (d\, I2-d\, z2)}{I2-2\, b\, I2-2\, W+2\, b\, W+z2} + \frac{A1 \left(\frac{g1}{g2}\right)^{\frac{a}{1-b}} (-I1+W)^{\frac{1}{1-b}} (-I2+W)^{-\frac{1}{1-b}} (d\, I1-d\, z1)\, (I2-z2) \left(d+\frac{d\, I2-d\, z2}{I2-2\, b\, I2-2\, W+2\, b\, W+z2}\right)}{(I1-2\, b\, I1-2\, W+2\, b\, W+z1) \left(d+\frac{d\, I1-d\, z1}{I1-2\, b\, I1-2\, W+2\, b\, W+z1}\right)} \right)}$$

$$n22 = \frac{A2\, N2\, (I1 - z1)\, (d\, I2 - d\, z2)}{(I2 - 2\, b\, I2 - 2\, W + 2\, b\, W + z2) \left(\frac{A2\, (I1-z1)\, (d\, I2-d\, z2)}{I2-2\, b\, I2-2\, W+2\, b\, W+z2} + \frac{A1 \left(\frac{g1}{g2}\right)^{\frac{a}{1-b}} (-I1+W)^{\frac{1}{1-b}} (-I2+W)^{-\frac{1}{1-b}} (d\, I1-d\, z1)\, (I2-z2) \left(d+\frac{d\, I2-d\, z2}{I2-2\, b\, I2-2\, W+2\, b\, W+z2}\right)}{(I1-2\, b\, I1-2\, W+2\, b\, W+z1) \left(d+\frac{d\, I1-d\, z1}{I1-2\, b\, I1-2\, W+2\, b\, W+z1}\right)} \right)}$$

Appendix C: Complete Results for Initial Model Specification in Chapter 3*

Variable	IV, Full Model	Pvestrtax Constrain to -1	Pvestrtax Constrain to -0.06	IV, Full Model, Fee Variables Lagged	Pvestrtax Constrain to -1, Fee Variables Lagged	Pvestrtax Constrain to -0.6, Fee Variables Lagged	IV, Age Replaced With Age Categories	IV, Age Replaced With Age Categories, Fee Variables Lagged	NL, Full Model	NL, Full, Fee Variables Lagged	NL, Full, Age Replaced With Age Categories	Minimum Value**	Maximum value**
pvestrtax	-0.80 *0.62*	-1.00 .	-0.60 .	-0.98 *0.68*	-1.00 .	-0.60 .	-0.94 *0.56*	-1.08 *0.65*	-0.32 *0.21*	-0.38 *0.17*	-0.31 *0.23*	-1.08 *0.17*	-0.31 *0.68*
lotsize	0.48 *0.00*	0.49 *0.00*	0.46 *0.00*	0.49 *0.01*	0.49 *0.00*	0.46 *0.00*	0.48 *0.00*	0.49 *0.01*	0.44 *0.00*	0.45 *0.00*	0.44 *0.00*	0.44 *0.00*	0.49 *0.01*
fsqft	66.52 *0.00*	69.27 *0.00*	63.77 *0.00*	69.32 *0.03*	69.55 *0.00*	64.05 *0.00*	68.58 *0.00*	70.84 *0.03*	61.11 *0.00*	62.49 *0.00*	60.99 *0.00*	60.99 *0.00*	70.84 *0.03*
ufsqft	41.95 *0.06*	44.73 *0.00*	39.17 *0.00*	44.59 *0.20*	44.83 *0.00*	39.28 *0.00*	44.26 *0.05*	46.34 *0.18*	33.95 *0.00*	34.68 *0.00*	34.18 *0.00*	33.95 *0.00*	46.34 *0.20*
baths	5210.54 *0.40*	5817.49 *0.00*	4604.32 *0.02*	5734.42 *0.56*	5785.95 *0.00*	4570.90 *0.02*	5751.77 *0.36*	6175.62 *0.52*	3115.17 *0.14*	3150.95 *0.14*	3203.80 *0.13*	3115.17 *0.00*	6175.62 *0.56*
gararea	80.89 *0.02*	85.28 *0.00*	76.51 *0.00*	83.59 *0.08*	83.96 *0.00*	75.17 *0.00*	83.95 *0.02*	85.66 *0.06*	69.94 *0.00*	69.73 *0.00*	69.79 *0.00*	69.73 *0.00*	85.66 *0.08*
ranch	4292.33 *0.00*	4247.58 *0.12*	4337.03 *0.11*	4058.19 *0.00*	4054.83 *0.14*	4133.99 *0.13*	4231.31 *0.00*	4002.92 *0.00*	4871.92 *0.11*	4743.19 *0.12*	4858.03 *0.11*	4002.92 *0.00*	4871.92 *0.14*
otherstyle	4983.43 *0.00*	4982.42 *0.10*	4984.43 *0.10*	4664.22 *0.00*	4664.61 *0.12*	4655.51 *0.12*	4659.63 *0.00*	4318.28 *0.00*	5464.64 *0.10*	5202.56 *0.12*	5189.98 *0.12*	4318.28 *0.00*	5464.64 *0.12*
age	-1601.34 *0.00*	-1641.44 *0.00*	-1561.29 *0.00*	-1592.81 *0.00*	-1596.25 *0.00*	-1515.07 *0.00*			-1568.40 *0.00*	-1543.56 *0.00*		-1641.44 *0.00*	-1515.07 *0.00*
age6to10							-9941.89 *0.01*	-10612.86 *0.03*			-8954.49 *0.02*	-10612.86 *0.01*	-8954.49 *0.03*
age11to15							-14908.82 *0.00*	-14731.15 *0.00*			-13957.53 *0.00*	-14908.82 *0.00*	-13957.53 *0.00*
age16to20							-25637.21 *0.00*	-25328.61 *0.00*			-25287.44 *0.00*	-25637.21 *0.00*	-25287.44 *0.00*
age21to30							-34093.52 *0.00*	-34159.89 *0.00*			-32864.98 *0.00*	-34159.89 *0.00*	-32864.98 *0.00*
d95	20286.01 *0.16*	21891.35 *0.00*	18682.62 *0.00*	21646.77 *0.28*	21791.70 *0.00*	18373.87 *0.00*	21021.77 *0.14*	22317.13 *0.26*	14823.57 *0.01*	14016.39 *0.03*	14426.50 *0.01*	14016.39 *0.00*	22317.13 *0.28*
d96	16107.90 *0.27*	14395.34 *0.02*	17818.37 *0.00*	13070.37 *0.48*	12949.10 *0.08*	15808.84 *0.03*	14128.52 *0.34*	11911.37 *0.51*	19117.60 *0.01*	15101.15 *0.10*	18596.45 *0.01*	11911.37 *0.00*	19117.60 *0.51*
d97	25097.10 *0.04*	24492.02 *0.00*	25701.44 *0.00*	28108.67 *0.00*	28067.71 *0.00*	29033.54 *0.00*	23882.11 *0.05*	27341.30 *0.00*	25022.88 *0.00*	27278.03 *0.00*	24468.23 *0.00*	23882.11 *0.00*	29033.54 *0.05*

Variable	IV, Full Model	Pvestrtax Constrain to -1	Pvestrtax Constrain to -0.06	IV, Full Model, Fee Variables Lagged	Pvestrtax Constrain to -1, Fee Variables Lagged	Pvestrtax Constrain to -0.6, Fee Variables Lagged	IV, Age Replaced With Age Categories	IV, Age Replaced With Age Categories, Fee Variables Lagged	NL, Full Model	NL, Full, Fee Variables Lagged	NL, Full, Age Replaced With Age Categories	Minimum Value**	Maximum value**
d98	**15275.51** *0.51*	**12330.10** *0.04*	**18217.32** *0.00*	**13670.28** *0.70*	**13433.74** *0.08*	**19011.66** *0.01*	**12368.68** *0.60*	**11708.70** *0.74*	**20752.77** *0.01*	**19453.56** *0.07*	**20346.66** *0.01*	**11708.70** *0.00*	**20752.77** *0.74*
d99	**26543.28** *0.20*	**24021.97** *0.00*	**29061.51** *0.00*	**25374.76** *0.39*	**25174.54** *0.00*	**29896.14** *0.00*	**24310.89** *0.24*	**24044.96** *0.41*	**31124.72** *0.00*	**30046.69** *0.00*	**31076.53** *0.00*	**24021.97** *0.00*	**31124.72** *0.41*
academy	**-211886.40** *0.15*	**-195258.40** *0.32*	**-228494.10** *0.24*	**-201513.00** *0.22*	**-200384.60** *0.26*	**-226993.70** *0.20*	**-208700.90** *0.15*	**-212018.80** *0.18*	**-268803.40** *0.22*	**-257329.70** *0.20*	**-277819.40** *0.20*	**-277819.40** *0.15*	**-195258.40** *0.32*
monument	**-122919.10** *0.01*	**-126914.00** *0.38*	**-118929.00** *0.41*	**-129009.40** *0.06*	**-129420.70** *0.25*	**-119722.40** *0.28*	**-126734.90** *0.01*	**-137087.40** *0.04*	**-122827.60** *0.45*	**-125826.60** *0.33*	**-123518.70** *0.45*	**-137087.40** *0.01*	**-118929.00** *0.45*
palmer1	**-110047.40** *0.19*	**-119438.90** *0.27*	**-100667.40** *0.35*	**-131899.40** *0.42*	**-133031.70** *0.12*	**-106329.60** *0.21*	**-117009.40** *0.16*	**-142570.90** *0.38*	**-89614.17** *0.47*	**-89007.54** *0.37*	**-89145.88** *0.47*	**-142570.90** *0.12*	**-89007.54** *0.47*
palmer2	**-107022.20** *0.08*	**-113597.70** *0.22*	**-100454.70** *0.27*	**-97334.03** *0.19*	**-97820.07** *0.18*	**-86358.31** *0.23*	**-109199.60** *0.08*	**-103392.00** *0.17*	**-93669.85** *0.36*	**-81820.39** *0.33*	**-90360.07** *0.38*	**-113597.70** *0.08*	**-81820.39** *0.38*
woodmoor	**176378.00** *0.04*	**182128.30** *0.13*	**170634.70** *0.16*	**93911.28** *0.18*	**94372.88** *0.25*	**83487.41** *0.31*	**185961.70** *0.02*	**95234.51** *0.14*	**193628.60** *0.16*	**93638.80** *0.33*	**199290.00** *0.15*	**83487.41** *0.02*	**199290.00** *0.33*
arrowwood	**-117076.40** *0.04*	**-122438.60** *0.15*	**-111720.60** *0.19*	**-125289.20** *0.09*	**-125776.90** *0.06*	**-114275.30** *0.09*	**-118122.60** *0.04*	**-132738.60** *0.08*	**-109149.90** *0.25*	**-114180.60** *0.15*	**-105460.50** *0.27*	**-132738.60** *0.04*	**-105460.50** *0.27*
blackforest	**-163238.80** *0.01*	**-168686.40** *0.05*	**-157797.80** *0.06*	**-171435.00** *0.02*	**-171931.30** *0.01*	**-160227.00** *0.02*	**-163545.20** *0.01*	**-178024.30** *0.02*	**-155796.10** *0.10*	**-160819.70** *0.04*	**-151236.40** *0.11*	**-178024.30** *0.01*	**-151236.40** *0.11*
falcon	**-181872.70** *0.02*	**-189955.90** *0.03*	**-173799.50** *0.05*	**-192709.70** *0.07*	**-193428.10** *0.01*	**-176486.60** *0.02*	**-183219.10** *0.02*	**-199846.80** *0.06*	**-121989.70** *0.20*	**-126687.20** *0.11*	**-117898.00** *0.21*	**-199846.80** *0.01*	**-117898.00** *0.21*
dwfire	**-126118.60** *0.01*	**-130034.50** *0.12*	**-122207.50** *0.15*	**-133131.60** *0.02*	**-133496.90** *0.05*	**-124882.20** *0.07*	**-125746.20** *0.01*	**-139552.00** *0.02*	**-166321.10** *0.10*	**-172180.90** *0.04*	**-160869.60** *0.11*	**-172180.90** *0.01*	**-122207.50** *0.15*
nofire	**-162304.30** *0.02*	**-169717.50** *0.05*	**-154900.20** *0.07*	**-172481.70** *0.08*	**-173143.10** *0.01*	**-157544.60** *0.02*	**-164646.00** *0.02*	**-180676.20** *0.07*	**-149466.30** *0.12*	**-155217.00** *0.05*	**-145622.60** *0.13*	**-180676.20** *0.01*	**-145622.60** *0.13*
cs1	**-336613.90** *0.02*	**-329398.90** *0.03*	**-343820.10** *0.03*	**-221719.80** *0.00*	**-221801.90** *0.03*	**-219864.70** *0.03*	**-325484.90** *0.02*	**-226965.50** *0.00*	**-373356.60** *0.03*	**-229114.20** *0.04*	**-363985.70** *0.03*	**-373356.60** *0.00*	**-219864.70** *0.04*
briargate	**-423445.90** *0.00*	**-414102.30** *0.01*	**-432778.00** *0.00*	**-260879.30** *0.00*	**-260829.60** *0.01*	**-262002.00** *0.01*	**-413339.30** *0.00*	**-270160.30** *0.00*	**-471627.20** *0.00*	**-276870.40** *0.01*	**-466079.30** *0.01*	**-471627.20** *0.00*	**-260829.60** *0.01*
norwood	**-493988.70** *0.00*	**-484692.40** *0.05*	**-503273.80** *0.04*	**-276373.30** *0.00*	**-276476.80** *0.03*	**-274034.80** *0.03*	**-489125.80** *0.00*	**-290618.50** *0.00*	**-538770.10** *0.05*	**-278937.20** *0.06*	**-537808.00** *0.05*	**-538770.10** *0.00*	**-274034.80** *0.06*
peregrine	**-434728.60** *0.06*	**-441786.90** *0.16*	**-427679.00** *0.18*	**-219367.70** *0.03*	**-219619.40** *0.16*	**-213683.70** *0.17*	**-433121.30** *0.06*	**-222737.00** *0.02*	**-501973.30** *0.16*	**-262206.40** *0.15*	**-492857.10** *0.17*	**-501973.30** *0.02*	**-213683.70** *0.18*
academynew	**325722.00** *0.02*	**334462.80** *0.59*	**316991.90** *0.61*	**288413.60** *0.02*	**288966.40** *0.60*	**275930.00** *0.61*	**353794.70** *0.01*	**311995.40** *0.01*	**337528.90** *0.62*	**304352.90** *0.62*	**357026.40** *0.60*	**275930.00** *0.01*	**357026.40** *0.62*
donalanew	**-110538.00** *0.01*	**-107855.50** *0.34*	**-113217.30** *0.31*	**-91755.27** *0.06*	**-91461.97** *0.33*	**-98378.58** *0.29*	**-104518.60** *0.02*	**-93185.25** *0.03*	**-128947.00** *0.31*	**-117229.00** *0.28*	**-123348.80** *0.33*	**-128947.00** *0.01*	**-91461.97** *0.34*

Variable	IV, Full Model	Pvestrtax Constrain to -1	Pvestrtax Constrain to -0.06	IV, Full Model, Fee Variables Lagged	Pvestrtax Constrain to -1, Fee Variables Lagged	Pvestrtax Constrain to -0.6, Fee Variables Lagged	IV, Age Replaced With Age Categories	IV, Age Replaced With Age Categories, Fee Variables Lagged	NL, Full Model	NL, Full, Fee Variables Lagged	NL, Full, Age Replaced With Age Categories	Minimum Value**	Maximum value**
monumentnew	**-75862.89**	**-76093.20**	**-75632.86**	**23480.87**	**23660.80**	**19417.61**	**-67960.81**	**28383.71**	**-83561.23**	**21129.80**	**-74504.34**	**-83561.23**	**28383.71**
	0.02	*0.70*	*0.70*	*0.50*	*0.85*	*0.87*	*0.04*	*0.38*	*0.71*	*0.88*	*0.74*	**0.02**	**0.88**
palmer1new	**99883.22**	**107336.20**	**92439.32**	**43912.98**	**44147.34**	**38620.70**	**110943.60**	**47877.55**	**95218.52**	**43549.72**	**100224.20**	**38620.70**	**110943.60**
	0.35	*0.47*	*0.53*	*0.68*	*0.74*	*0.78*	*0.31*	*0.66*	*0.58*	*0.78*	*0.55*	*0.31*	*0.78*
palmer2new	**6443.60**	**8125.17**	**4764.09**	**2983.35**	**3136.92**	**-484.58**	**10876.91**	**5596.51**	**3620.73**	**-4127.34**	**6822.87**	**-4127.34**	**10876.91**
	0.79	*0.93*	*0.96*	*0.91*	*0.97*	*1.00*	*0.65*	*0.83*	*0.97*	*0.96*	*0.95*	*0.65*	*1.00*
woodmoornew	**-6913.17**	**-8499.24**	**-5329.04**	**1947.29**	**1906.19**	**2875.30**	**-13803.75**	**-776.04**	**7774.93**	**11992.06**	**1158.09**	**-13803.75**	**11992.06**
	0.93	*0.96*	*0.98*	*0.97*	*0.99*	*0.98*	*0.86*	*0.99*	*0.97*	*0.92*	*1.00*	*0.86*	*1.00*
arrowwoodnew	**10568.79**	**10153.89**	**10983.18**	**10534.95**	**10500.74**	**11307.67**	**14368.80**	**14270.27**	**13375.50**	**13852.73**	**17328.26**	**10153.89**	**17328.26**
	0.21	*0.40*	*0.37*	*0.26*	*0.39*	*0.35*	*0.08*	*0.11*	*0.31*	*0.31*	*0.19*	*0.08*	*0.40*
blackforestnew	**-11082.55**	**-11314.25**	**-10851.13**	**-10528.73**	**-10546.99**	**-10116.47**	**-7398.14**	**-7013.18**	**-11001.44**	**-10482.65**	**-7271.42**	**-11314.25**	**-7013.18**
	0.28	*0.51*	*0.53*	*0.31*	*0.54*	*0.56*	*0.46*	*0.49*	*0.56*	*0.59*	*0.70*	*0.28*	*0.70*
falconnew	**-54683.07**	**-55554.74**	**-53812.45**	**-55034.05**	**-55108.99**	**-53341.75**	**-52047.19**	**-52402.98**	**-4182.96**	**-3718.77**	**-761.99**	**-55554.74**	**-761.99**
	0.00	*0.28*	*0.29*	*0.00*	*0.28*	*0.30*	*0.00*	*0.00*	*0.64*	*0.68*	*0.93*	*0.00*	*0.93*
dwfirenew	**-2823.79**	**-2567.51**	**-3079.77**	**-2154.82**	**-2134.36**	**-2616.85**	**905.08**	**1369.88**	**-56438.13**	**-56896.46**	**-53122.90**	**-56896.46**	**1369.88**
	0.45	*0.75*	*0.70*	*0.63*	*0.79*	*0.75*	*0.83*	*0.78*	*0.31*	*0.32*	*0.34*	*0.31*	*0.83*
nofirenew	**1574.15**	**364.83**	**2781.99**	**1085.95**	**980.79**	**3460.65**	**5185.76**	**4587.05**	**5152.27**	**5703.83**	**9658.61**	**364.83**	**9658.61**
	0.95	*0.99*	*0.91*	*0.97*	*0.97*	*0.89*	*0.82*	*0.85*	*0.85*	*0.84*	*0.73*	*0.73*	*0.99*
cs1new	**-355934.30**	**-356596.70**	**-355272.60**	**-105937.10**	**-105980.50**	**-104958.50**	**-343551.20**	**-99344.32**	**-405413.30**	**-124306.80**	**-394416.30**	**-405413.30**	**-99344.32**
	0.26	*0.09*	*0.09*	*0.38*	*0.21*	*0.21*	*0.28*	*0.42*	*0.09*	*0.19*	*0.09*	*0.09*	*0.42*
briargatenew	**-90866.72**	**-99252.28**	**-82491.40**	**85644.77**	**85288.06**	**93700.07**	**-82562.28**	**95182.22**	**-87223.06**	**109833.00**	**-74831.95**	**-99252.28**	**109833.00**
	0.41	*0.47*	*0.55*	*0.27*	*0.11*	*0.08*	*0.43*	*0.24*	*0.57*	*0.07*	*0.63*	*0.07*	*0.63*
norwoodnew	**-221834.70**	**-225767.70**	**-217906.60**	**-91092.26**	**-91025.11**	**-92608.69**	**-206486.10**	**-76239.87**	**-261454.40**	**-126058.10**	**-243761.00**	**-261454.40**	**-76239.87**
	0.04	*0.67*	*0.68*	*0.06*	*0.68*	*0.67*	*0.05*	*0.15*	*0.66*	*0.62*	*0.68*	*0.04*	*0.68*
peregrinenew	**-603237.10**	**-600593.00**	**-605878.00**	**-237344.30**	**-237078.20**	**-243353.90**	**-591244.70**	**-231901.90**	**-715026.10**	**-300854.70**	**-699772.10**	**-715026.10**	**-231901.90**
	0.03	*0.17*	*0.17*	*0.07*	*0.19*	*0.18*	*0.04*	*0.07*	*0.15*	*0.16*	*0.16*	*0.03*	*0.19*
academyrfee	**10.44**	**8.79**	**12.08**	**8.76**	**8.65**	**11.29**	**10.26**	**9.18**	**15.52**	**13.59**	**16.61**	**8.65**	**16.61**
	0.44	*0.59*	*0.45*	*0.59*	*0.54*	*0.43*	*0.45*	*0.57*	*0.39*	*0.40*	*0.35*	*0.35*	*0.59*
donalarfee	**-9.94**	**-10.10**	**-9.78**	**-10.71**	**-10.73**	**-10.33**	**-9.84**	**-11.30**	**-10.09**	**-10.78**	**-9.82**	**-11.30**	**-9.78**
	0.01	*0.21*	*0.22*	*0.00*	*0.10*	*0.12*	*0.01*	*0.00*	*0.26*	*0.16*	*0.27*	*0.00*	*0.27*
monumentrfee	**0.73**	**0.81**	**0.66**	**0.76**	**0.77**	**0.55**	**1.05**	**0.89**	**0.95**	**0.88**	**1.26**	**0.55**	**1.26**
	0.69	*0.93*	*0.94*	*0.72*	*0.91*	*0.94*	*0.57*	*0.65*	*0.92*	*0.91*	*0.90*	*0.57*	*0.94*
palmer1rfee	**1.23**	**2.04**	**0.41**	**2.91**	**3.01**	**0.70**	**2.00**	**3.39**	**-1.02**	**-1.39**	**-0.84**	**-1.39**	**3.39**
	0.86	*0.73*	*0.94*	*0.83*	*0.54*	*0.89*	*0.77*	*0.80*	*0.88*	*0.81*	*0.90*	*0.54*	*0.94*
palmer2rfee	**0.20**	**0.45**	**-0.05**	**-1.90**	**-1.89**	**-2.14**	**0.35**	**-2.06**	**-0.68**	**-2.84**	**-0.70**	**-2.84**	**0.45**
	0.93	*0.92*	*0.99*	*0.31*	*0.62*	*0.58*	*0.88*	*0.26*	*0.89*	*0.51*	*0.88*	*0.26*	*0.99*

Variable	IV, Full Model	Pvestrtax Constrain to -1	Pvestrtax Constrain to -0.06	IV, Full Model, Fee Variables Lagged	Pvestrtax Constrain to -1, Fee Variables Lagged	Pvestrtax Constrain to -0.6, Fee Variables Lagged	IV, Age Replaced With Age Categories	IV, Age Replaced With Age Categories, Fee Variables Lagged	NL, Full Model	NL, Full, Fee Variables Lagged	NL, Full, Age Replaced With Age Categories	Minimum Value**	Maximum value**
woodmoorrfee	**-22.01**	**-22.62**	**-21.39**	**-16.19**	**-16.24**	**-14.97**	**-22.74**	**-16.83**	**-23.49**	**-16.18**	**-23.73**	**-23.73**	**-14.97**
	0.01	*0.01*	*0.01*	*0.05*	*0.00*	*0.01*	*0.01*	*0.03*	*0.01*	*0.02*	*0.01*	*0.00*	*0.05*
cs1rfee	**43.67**	**41.55**	**45.77**	**19.38**	**19.34**	**20.47**	**41.39**	**18.99**	**51.48**	**21.78**	**50.24**	**18.99**	**51.48**
	0.10	*0.06*	*0.04*	*0.01*	*0.06*	*0.05*	*0.11*	*0.00*	*0.04*	*0.06*	*0.04*	*0.00*	*0.11*
briargaterfee	**59.34**	**56.85**	**61.83**	**25.60**	**25.53**	**27.19**	**57.36**	**26.09**	**69.31**	**29.53**	**68.83**	**25.53**	**69.31**
	0.03	*0.01*	*0.00*	*0.01*	*0.01*	*0.01*	*0.03*	*0.01*	*0.00*	*0.01*	*0.00*	*0.00*	*0.03*
norwoodrfee	**73.60**	**71.13**	**76.06**	**29.00**	**28.96**	**29.90**	**72.67**	**30.47**	**82.85**	**30.32**	**83.28**	**28.96**	**83.28**
	0.01	*0.11*	*0.09*	*0.00*	*0.12*	*0.11*	*0.01*	*0.00*	*0.09*	*0.15*	*0.09*	*0.00*	*0.15*
peregrinerfee	**76.91**	**78.77**	**75.05**	**33.70**	**33.78**	**31.86**	**77.43**	**33.65**	**87.70**	**39.25**	**86.49**	**31.86**	**87.70**
	0.08	*0.18*	*0.20*	*0.10*	*0.19*	*0.22*	*0.08*	*0.09*	*0.19*	*0.20*	*0.20*	*0.08*	*0.22*
academynewrfee	**-30.84**	**-31.59**	**-30.09**	**-26.33**	**-26.38**	**-25.32**	**-32.98**	**-28.03**	**-32.15**	**-28.01**	**-33.55**	**-33.55**	**-25.32**
	0.01	*0.57*	*0.59*	*0.01*	*0.58*	*0.60*	*0.01*	*0.01*	*0.61*	*0.61*	*0.59*	*0.01*	*0.61*
donalanewrfee	**11.95**	**11.67**	**12.22**	**10.43**	**10.40**	**11.11**	**11.75**	**10.95**	**13.92**	**13.18**	**13.77**	**10.40**	**13.92**
	0.01	*0.28*	*0.26*	*0.03*	*0.26*	*0.23*	*0.01*	*0.01*	*0.25*	*0.22*	*0.25*	*0.01*	*0.28*
monumentnewrfee	**5.15**	**5.15**	**5.14**	**-1.98**	**-1.99**	**-1.65**	**4.84**	**-2.07**	**5.72**	**-1.74**	**5.34**	**-2.07**	**5.72**
	0.03	*0.72*	*0.72*	*0.48*	*0.83*	*0.86*	*0.04*	*0.42*	*0.72*	*0.87*	*0.74*	*0.03*	*0.87*
palmer1newrfee	**-9.19**	**-9.70**	**-8.68**	**-4.49**	**-4.50**	**-4.32**	**-9.65**	**-4.37**	**-9.20**	**-5.13**	**-9.24**	**-9.70**	**-4.32**
	0.26	*0.43*	*0.48*	*0.60*	*0.70*	*0.71*	*0.25*	*0.62*	*0.51*	*0.71*	*0.51*	*0.25*	*0.71*
palmer2newrfee	**-3.68**	**-3.94**	**-3.42**	**-4.02**	**-4.05**	**-3.37**	**-3.75**	**-3.90**	**-3.40**	**-3.02**	**-3.28**	**-4.05**	**-3.02**
	0.26	*0.73*	*0.76*	*0.38*	*0.70*	*0.75*	*0.24*	*0.38*	*0.79*	*0.80*	*0.79*	*0.24*	*0.80*
woodmoornewrfee	**0.98**	**1.12**	**0.84**	**0.23**	**0.23**	**0.15**	**1.91**	**0.81**	**-0.18**	**-0.56**	**0.71**	**-0.56**	**1.91**
	0.88	*0.94*	*0.95*	*0.96*	*0.98*	*0.99*	*0.77*	*0.84*	*0.99*	*0.96*	*0.97*	*0.77*	*0.99*
cs1newrfee	**69.84**	**70.01**	**69.67**	**20.62**	**20.63**	**20.37**	**68.33**	**20.21**	**79.44**	**24.05**	**78.13**	**20.21**	**79.44**
	0.26	*0.08*	*0.08*	*0.37*	*0.17*	*0.17*	*0.27*	*0.39*	*0.08*	*0.16*	*0.08*	*0.08*	*0.39*
briargatenewrfee	**18.01**	**19.67**	**16.36**	**-15.70**	**-15.63**	**-17.26**	**17.22**	**-16.77**	**17.32**	**-20.26**	**15.74**	**-20.26**	**19.67**
	0.43	*0.46*	*0.54*	*0.24*	*0.12*	*0.09*	*0.42*	*0.23*	*0.57*	*0.08*	*0.60*	*0.08*	*0.60*
norwoodnewrfee	**39.95**	**40.89**	**39.01**	**14.28**	**14.28**	**14.24**	**37.82**	**12.20**	**46.65**	**19.66**	**44.00**	**12.20**	**46.65**
	0.06	*0.69*	*0.70*	*0.09*	*0.72*	*0.72*	*0.06*	*0.17*	*0.68*	*0.67*	*0.70*	*0.06*	*0.72*
peregrinenewrfee	**122.81**	**122.33**	**123.29**	**50.26**	**50.21**	**51.34**	**121.23**	**49.90**	**145.08**	**62.90**	**142.82**	**49.90**	**145.08**
	0.03	*0.15*	*0.15*	*0.04*	*0.15*	*0.14*	*0.03*	*0.04*	*0.14*	*0.13*	*0.14*	*0.03*	*0.15*

Variable	IV, Full Model	Pvestrtax Constrain to -1	Pvestrtax Constrain to -0.06	IV, Full Model, Fee Variables Lagged	Pvestrtax Constrain to -1, Fee Variables Lagged	Pvestrtax Constrain to -0.6, Fee Variables Lagged	IV, Age Replaced With Age Categories	IV, Age Replaced With Age Categories, Fee Variables Lagged	NL, Full Model	NL, Full, Fee Variables Lagged	NL, Full, Age Replaced With Age Categories	Minimum Value**	Maximum value**
Constant	128731.90	133974.20	123496.00	135718.30	136181.30	125265.00	125586.10	138861.70	123991.10	129545.30	115953.30	115953.30	138861.70
	0.01	*0.11*	*0.14*	*0.05*	*0.04*	*0.06*	*0.02*	*0.05*	*0.19*	*0.09*	*0.22*	*0.01*	*0.22*
R^2	0.34			0.34			0.34	0.34	0.84	0.84	0.84	0.34	0.84
# obs	12306.00	12306.00	12306.00	12306.00	12306.00	12306.00	12306.00	12306.00	12306.00	12306.00	12306.00	12306.00	12306.00

*Probability values are listed below the coefficients.

**Probability values in the minimum and maximum columns do not correspond to minimum and maximum levels for the coefficients in these columns. The minimum and maximum significance levels are intended to illustrate the range of significance across estimations for the listed variable.

Appendix D: Complete Results for the Reformulated Model in Chapter 3*

Variable	IV, Rfee, Rfeenew, Avgrfee	IV, Lrfee, Lrfeenew. Lavgrfee	IV, Age Categories, Rfee, Rfeenew, Avgrfee	IV, Age Categories, Lrfee, Lrfeenew. Lavgrfee	NL, Rfee, Rfeenew, Avgrfee	NL, Lrfee, Lrfeenew. Lavgrfee	NL, Age Categories, Rfee, Rfeenew, Avgrfee	NL, Age Categories, Lrfee, Lrfeenew. Lavgrfee	Minimum Value**	Maximum Value**
pvestrtax	-1.20	-1.36	-1.24	-1.42	-0.26	-0.27	-0.25	-0.26	-1.42	-0.25
	0.34	*0.30*	*0.33*	*0.28*	*0.24*	*0.23*	*0.26*	*0.25*	*0.23*	*0.34*
lotsize	0.51	0.52	0.51	0.52	0.45	0.45	0.44	0.44	0.44	0.52
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
fsqft	72.44	74.54	73.00	75.55	60.43	60.60	60.34	60.54	60.34	75.55
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
ufsqft	47.29	49.45	48.05	50.67	33.04	33.16	33.25	33.38	33.04	50.67
	0.01	*0.01*	*0.01*	*0.01*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.01*
baths	6104.26	6603.30	6315.26	6915.51	2676.94	2707.74	2759.95	2788.25	2676.94	6915.51
	0.30	*0.29*	*0.28*	*0.27*	*0.20*	*0.19*	*0.18*	*0.18*	*0.18*	*0.30*
gararea	88.71	92.01	89.27	93.28	67.76	67.94	67.65	67.89	67.65	93.28
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
ranch	3897.00	3901.89	3863.10	3845.84	4503.75	4551.75	4517.64	4564.69	3845.84	4564.69
	0.01	*0.01*	*0.01*	*0.01*	*0.13*	*0.12*	*0.12*	*0.12*	*0.01*	*0.13*
otherstyle	4624.26	4652.29	4267.97	4275.21	5093.23	5156.81	4856.84	4929.76	4267.97	5156.81
	0.00	*0.00*	*0.00*	*0.00*	*0.12*	*0.11*	*0.13*	*0.13*	*0.00*	*0.13*
age	-1655.90	-1678.70			-1520.42	-1519.14			-1678.70	-1519.14
	0.00	*0.00*			*0.00*	*0.00*			*0.00*	*0.00*
new	1186.78	1205.62			880.46	865.66			865.66	1205.62
	0.80	*0.81*			*0.86*	*0.87*			*0.80*	*0.87*
age1to5			-4903.94	-4930.88			-4549.90	-4514.27	-4930.88	-4514.27
			0.28	*0.32*			*0.36*	*0.38*	*0.28*	*0.38*
age6to10			-15807.24	-16261.42			-13354.66	-13300.02	-16261.42	-13300.02
			0.01	*0.02*			*0.01*	*0.02*	*0.01*	*0.02*
age11to15			-20645.12	-21077.31			-18359.27	-18328.60	-21077.31	-18328.60
			0.00	*0.00*			*0.00*	*0.00*	*0.00*	*0.00*

Variable	IV, Rfee, Rfeenew, Avgrfee	IV, Lrfee, Lrfeenew. Lavgrfee	IV, Age Categories, Rfee, Rfeenew, Avgrfee	IV, Age Categories, Lrfee, Lrfeenew. Lavgrfee	NL, Rfee, Rfeenew, Avgrfee	NL, Lrfee, Lrfeenew. Lavgrfee	NL, Age Categories, Rfee, Rfeenew, Avgrfee	NL, Age Categories, Lrfee, Lrfeenew. Lavgrfee	Minimum Value**	Maximum Value**
age16to20			**-30636.34** *0.00*	**-31069.98** *0.00*			**-28965.17** *0.00*	**-29016.86** *0.00*	**-31069.98** *0.00*	**-28965.17** *0.00*
age21to30			**-39886.82** *0.00*	**-40420.64** *0.00*			**-36673.96** *0.00*	**-36546.13** *0.00*	**-40420.64** *0.00*	**-36546.13** *0.00*
d95	**-27677.88** *0.52*	**12668.29** *0.21*	**-24853.61** *0.56*	**13457.63** *0.18*	**-19351.85** *0.78*	**1845.99** *0.90*	**-16686.38** *0.81*	**2207.49** *0.88*	**-27677.88** *0.18*	**13457.63** *0.90*
d96	**-46764.23** *0.44*	**-4749.26** *0.90*	**-44658.22** *0.45*	**-3172.55** *0.93*	**-22762.53** *0.76*	**8046.61** *0.91*	**-20002.97** *0.79*	**10844.72** *0.88*	**-46764.23** *0.44*	**10844.72** *0.93*
d97	**-29750.24** *0.54*	**10432.56** *0.75*	**-27786.06** *0.56*	**12344.46** *0.70*	**-12104.54** *0.86*	**17918.50** *0.82*	**-9647.15** *0.89*	**20760.04** *0.79*	**-29750.24** *0.54*	**20760.04** *0.89*
d98	**-43422.31** *0.47*	**-7559.57** *0.86*	**-42053.47** *0.48*	**-6630.92** *0.88*	**-16170.03** *0.80*	**11881.94** *0.87*	**-13745.29** *0.83*	**14659.35** *0.84*	**-43422.31** *0.47*	**14659.35** *0.88*
d99	**-30992.31** *0.58*	**3990.11** *0.92*	**-29297.21** *0.60*	**5274.96** *0.90*	**-6292.15** *0.92*	**20800.10** *0.77*	**-3620.43** *0.95*	**23770.46** *0.73*	**-30992.31** *0.58*	**23770.46** *0.95*
academy	**-2315.32** *0.75*	**-1338.24** *0.87*	**-2508.32** *0.72*	**-1331.13** *0.86*	**-7240.41** *0.52*	**-7069.12** *0.53*	**-7365.82** *0.51*	**-7109.13** *0.53*	**-7365.82** *0.51*	**-1331.13** *0.87*
monument	**-23868.67** *0.00*	**-21861.40** *0.00*	**-24306.08** *0.00*	**-22104.60** *0.00*	**-18989.20** *0.17*	**-14551.44** *0.23*	**-18880.48** *0.17*	**-14046.92** *0.25*	**-24306.08** *0.00*	**-14046.92** *0.25*
palmer1	**7393.28** *0.70*	**10259.50** *0.58*	**7454.59** *0.69*	**10989.24** *0.55*	**-6150.99** *0.59*	**-3980.18** *0.71*	**-6393.81** *0.58*	**-3942.34** *0.71*	**-6393.81** *0.55*	**10989.24** *0.71*
palmer2	**-15470.27** *0.44*	**-17414.14** *0.38*	**-15731.34** *0.44*	**-18455.41** *0.36*	**-1290.91** *0.93*	**-2332.32** *0.88*	**-821.38** *0.96*	**-2139.16** *0.89*	**-18455.41** *0.36*	**-821.38** *0.96*
woodmoor	**2261.91** *0.62*	**3853.35** *0.34*	**1746.93** *0.69*	**3586.05** *0.36*	**538.82** *0.95*	**3050.49** *0.64*	**210.71** *0.98*	**2958.21** *0.65*	**210.71** *0.34*	**3853.35** *0.98*
arrowwood	**-14661.39** *0.70*	**-25987.63** *0.45*	**-13972.95** *0.71*	**-27442.70** *0.43*	**11294.54** *0.72*	**-2225.77** *0.92*	**12720.76** *0.69*	**-2097.35** *0.93*	**-27442.70** *0.43*	**12720.76** *0.93*
blackforest	**-68042.11** *0.08*	**-79235.90** *0.02*	**-66680.20** *0.08*	**-80001.73** *0.02*	**-43703.27** *0.19*	**-57177.15** *0.02*	**-41566.89** *0.21*	**-56346.63** *0.02*	**-80001.73** *0.02*	**-41566.89** *0.21*

Variable	IV, Rfee, Rfeenew, Avgrfee	IV, Lrfee, Lrfeenew. Lavgrfee	IV, Age Categories, Rfee, Rfeenew, Avgrfee	IV, Age Categories, Lrfee, Lrfeenew. Lavgrfee	NL, Rfee, Rfeenew, Avgrfee	NL, Lrfee, Lrfeenew. Lavgrfee	NL, Age Categories, Rfee, Rfeenew, Avgrfee	NL, Age Categories, Lrfee, Lrfeenew. Lavgrfee	Minimum Value**	Maximum Value**
falcon	-106127.80	-119376.30	-104595.50	-120438.10	-67937.51	-81450.15	-65074.07	-79911.16	-120438.10	-65074.07
	0.06	*0.03*	*0.06*	*0.03*	*0.10*	*0.02*	*0.12*	*0.02*	*0.02*	*0.12*
dwfire	-21777.98	-32325.49	-20755.44	-33201.52	-4174.16	-17947.18	-2616.38	-17673.55	-33201.52	-2616.38
	0.46	*0.22*	*0.48*	*0.20*	*0.89*	*0.39*	*0.93*	*0.39*	*0.20*	*0.93*
nofire	-66085.68	-79233.16	-65465.09	-81072.48	-30251.29	-43984.55	-28618.80	-43672.10	-81072.48	-28618.80
	0.20	*0.10*	*0.20*	*0.09*	*0.37*	*0.08*	*0.39*	*0.08*	*0.08*	*0.39*
cs1	-12080.14	-18069.58	-12336.47	-19434.98	369.45	-6794.01	854.18	-6938.88	-19434.98	854.18
	0.52	*0.28*	*0.52*	*0.25*	*0.98*	*0.53*	*0.96*	*0.52*	*0.25*	*0.98*
briargate	-19557.90	-25423.02	-19239.04	-26123.79	-8038.20	-15219.90	-7432.94	-15261.41	-26123.79	-7432.94
	0.25	*0.08*	*0.25*	*0.07*	*0.62*	*0.16*	*0.64*	*0.15*	*0.07*	*0.64*
norwood	-18766.53	-24458.86	-18366.02	-25029.15	-8649.92	-15835.31	-8064.99	-15899.46	-25029.15	-8064.99
	0.25	*0.08*	*0.25*	*0.07*	*0.60*	*0.18*	*0.63*	*0.17*	*0.07*	*0.63*
peregrine	79316.09	77972.52	80643.38	79268.58	62984.87	56109.50	63299.47	55830.13	55830.13	80643.38
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
rfee	3.95	-0.38	3.78	-0.64	3.04	-0.65	2.85	-0.93	-0.93	3.95
	0.23	*0.84*	*0.25*	*0.73*	*0.55*	*0.90*	*0.58*	*0.85*	*0.23*	*0.90*
rfeenew	0.68	0.70	0.71	0.73	0.72	0.74	0.76	0.78	0.68	0.78
	0.03	*0.04*	*0.02*	*0.03*	*0.31*	*0.32*	*0.29*	*0.29*	*0.02*	*0.32*
avgrfee	45.96	-2.62	42.59	-5.25	22.66	-10.78	19.23	-13.80	-13.80	45.96
	0.46	*0.94*	*0.48*	*0.87*	*0.79*	*0.88*	*0.82*	*0.85*	*0.46*	*0.94*
constant	-215269.70	68521.65	-195932.50	85440.73	-103816.70	95888.52	-85664.21	112509.20	-215269.70	112509.20
	0.51	*0.67*	*0.53*	*0.59*	*0.82*	*0.81*	*0.85*	*0.77*	*0.51*	*0.85*
R^2	0.34	0.34	0.34	0.33	0.84	0.84	0.84	0.84	0.33	0.84
# obs	12306	12306	12306	12306	12306	12306	12306	12306	12306.00	12306.00

*Probability values are listed below the coefficients.

**Probability values in the minimum and maximum columns do not correspond to minimum and maximum levels for the coefficients in these columns. The minimum and maximum significance levels are intended to illustrate the range of significance across estimations for the listed variable.

Appendix E: Average Community Characteristics from Chapter 4

District	# Obs	Mean Nom Price	Mean Real Price	Mean Lot Size	Mean Fin Sqft	Mean Unfin Sqft	Mean Baths	Mean Garage	Mean Age	% New	% Two Story	% Ranch	% Other Style
aca94	32	$160,815	$205,612	23694	2329	470	2.8	539	11.6	16%	38%	22%	41%
aca95	23	$185,216	$227,043	24661	2752	321	3.3	546	10.0	17%	52%	17%	30%
aca96	14	$187,257	$221,749	24285	2579	403	3.0	493	12.4	0%	57%	14%	29%
aca97	19	$189,741	$217,584	23046	2376	502	3.0	538	12.6	11%	53%	21%	26%
aca98	23	$197,796	$221,497	26382	2480	490	2.8	562	12.3	9%	48%	22%	30%
aca99	19	$211,737	$230,420	24333	2642	429	3.1	565	14.0	0%	47%	37%	16%
don94	122	$184,392	$235,757	12207	2643	638	3.2	533	3.2	55%	79%	15%	7%
don95	89	$187,971	$230,420	13223	2514	600	3.1	530	5.3	30%	60%	24%	17%
don96	129	$206,568	$244,617	12956	2730	616	3.2	541	4.6	30%	71%	22%	7%
don97	159	$225,857	$259,000	15438	2725	660	3.2	564	4.2	43%	69%	26%	6%
don98	194	$240,088	$268,857	15439	2776	767	3.2	580	4.0	42%	73%	24%	3%
don99	178	$267,926	$291,566	16278	2876	798	3.2	616	3.2	46%	71%	25%	4%
mon94	22	$116,312	$148,712	10529	1570	614	2.4	407	5.0	50%	59%	32%	9%
mon95	21	$149,249	$182,954	10337	1922	637	2.9	461	3.1	67%	81%	10%	10%
mon96	37	$158,744	$187,984	11163	1773	833	2.8	472	2.7	70%	73%	22%	5%
mon97	16	$154,072	$176,681	10228	1808	592	2.6	382	7.5	44%	50%	31%	19%
mon98	25	$156,768	$175,553	9236	1706	450	2.6	397	5.2	12%	76%	16%	8%
mon99	14	$150,845	$164,155	10720	1517	381	2.4	465	9.7	7%	29%	71%	0%
pal194	20	$122,470	$156,585	28913	1841	366	2.1	349	8.9	20%	10%	60%	30%
pal195	37	$135,733	$166,385	12533	1719	501	2.0	442	8.5	19%	22%	57%	22%
pal196	29	$150,345	$178,038	19785	1708	573	2.2	422	7.4	21%	17%	72%	10%
pal197	28	$149,158	$171,046	18600	1749	440	2.1	447	9.3	14%	18%	54%	29%
pal198	35	$149,373	$167,272	18669	1592	559	2.0	379	12.5	14%	17%	60%	23%

District	# Obs	Mean Nom Price	Mean Real Price	Mean Lot Size	Mean Fin Sqft	Mean Unfin Sqft	Mean Baths	Mean Garage	Mean Age	% New	% Two Story	% Ranch	% Other Style
pal199	28	$177,399	$193,051	19142	1763	704	2.2	413	8.5	4%	11%	75%	14%
pal294	18	$196,391	$251,098	57197	2661	605	3.1	661	10.6	22%	33%	61%	6%
pal295	15	$234,877	$287,919	64068	2957	698	3.0	554	13.5	13%	47%	40%	13%
pal296	15	$262,529	$310,885	62861	3043	700	3.3	730	6.2	13%	47%	53%	0%
pal297	12	$233,189	$267,408	65645	2771	756	3.0	654	9.3	8%	50%	33%	17%
pal298	10	$269,130	$301,379	89775	3041	793	2.9	688	11.0	0%	50%	40%	10%
pal299	16	$262,189	$285,324	71389	2730	770	3.0	631	12.9	19%	38%	44%	19%
wood94	224	$236,956	$302,963	29592	3355	582	3.4	667	6.0	30%	62%	33%	5%
wood95	155	$237,616	$291,277	27667	3145	652	3.3	666	6.1	21%	66%	27%	6%
wood96	180	$251,481	$297,802	29227	3349	619	3.4	692	6.8	15%	66%	29%	5%
wood97	165	$255,232	$292,686	28962	3201	584	3.3	701	8.0	17%	61%	33%	6%
wood98	202	$262,868	$294,367	28849	3256	671	3.3	676	9.4	14%	54%	40%	6%
wood99	215	$268,532	$292,226	29757	3182	648	3.3	667	10.8	6%	55%	38%	7%
arrow94	59	$216,228	$276,460	111183	2931	726	3.1	648	5.7	46%	54%	36%	10%
arrow95	46	$250,111	$306,593	115707	3053	711	3.1	699	4.4	43%	54%	41%	4%
arrow96	48	$291,267	$344,916	103250	3314	817	3.2	726	4.8	40%	56%	40%	4%
arrow97	54	$330,326	$378,799	113646	3812	644	3.7	744	5.2	46%	63%	28%	9%
arrow98	51	$318,574	$356,748	115318	3456	821	3.4	770	6.0	30%	65%	30%	6%
arrow99	65	$360,111	$391,885	115673	3675	602	3.5	749	5.9	11%	58%	38%	3%
black94	36	$198,999	$254,433	193268	2760	585	2.8	641	8.1	36%	25%	61%	14%
black95	34	$208,796	$255,948	176406	2500	820	2.9	703	6.2	38%	24%	59%	18%
black96	36	$229,102	$271,302	195488	2635	758	2.7	683	9.3	22%	36%	53%	11%
black97	25	$245,614	$281,656	175056	2765	555	2.8	665	9.2	20%	24%	60%	16%
black98	37	$267,464	$299,514	187386	2828	1020	2.8	693	6.8	30%	49%	46%	5%
black99	31	$250,687	$272,806	201826	2501	514	2.7	535	13.5	10%	39%	48%	13%

District	# Obs	Mean Nom Price	Mean Real Price	Mean Lot Size	Mean Fin Sqft	Mean Unfin Sqft	Mean Baths	Mean Garage	Mean Age	% New	% Two Story	% Ranch	% Other Style
falcon94	5	$168,680	$247,324	215883	2476	0	2.6	758	12.0	20%	60%	0%	40%
falcon95	2	$167,772	$247,743	217800	2785	443	2.5	662	11.5	50%	0%	100%	0%
falcon96	3	$225,208	$292,597	214170	2181	1415	2.3	672	6.0	33%	0%	67%	33%
falcon97	4	$216,625	$270,983	217800	2184	838	2.5	473	7.8	50%	0%	75%	25%
falcon98	4	$223,125	$265,150	217800	2419	1133	2.5	608	8.8	25%	25%	75%	0%
falcon99	3	$261,667	$293,351	217800	2611	251	3.3	677	13.7	0%	33%	33%	34%
dwfire94	15	$187,784	$275,335	65378	2904	453	3.1	546	13.2	13%	47%	27%	26%
dwfire95	75	$189,001	$259,940	30714	2556	627	3.1	544	5.1	64%	64%	26%	10%
dwfire96	164	$189,878	$246,695	22973	2560	654	3.0	553	3.4	21%	29%	64%	7%
dwfire97	173	$193,268	$241,764	18784	2393	700	3.0	523	2.6	58%	69%	26%	5%
dwfire98	172	$203,152	$241,415	23867	2380	742	3.0	518	2.8	52%	69%	22%	9%
dwfire99	128	$212,489	$238,209	24483	2371	694	3.0	526	3.7	18%	70%	23%	7%
nofire94	12	$164,571	$241,299	81390	2320	670	3.2	521	6.8	8%	58%	25%	17%
nofire95	10	$178,866	$246,002	164713	2297	665	2.4	641	5.6	4%	3%	6%	91%
nofire96	14	$183,433	$238,321	94994	2108	802	2.6	614	7.6	21%	29%	64%	7%
nofire97	15	$183,070	$229,008	156566	2124	817	2.4	681	10.9	6%	27%	73%	0%
nofire98	28	$261,705	$310,996	108057	2695	740	2.8	645	8.1	29%	54%	36%	10%
nofire99	26	$250,677	$281,020	131616	2749	717	3.0	645	8.3	19%	62%	27%	11%
cs194	662	$164,072	$240,568	11453	2424	462	3.0	519	7.6	32%	51%	18%	31%
cs195	498	$165,805	$228,038	12106	2357	451	2.8	515	9.7	16%	46%	19%	35%
cs196	540	$177,723	$230,903	122209	2413	478	2.9	520	10.3	12%	50%	19%	31%
cs197	423	$181,431	$226,957	12503	2381	400	2.9	522	11.6	6%	45%	23%	32%
cs198	467	$187,679	$223,028	12308	2384	424	2.8	525	13.2	5%	43%	19%	38%
cs199	404	$196,547	$220,338	12374	2380	444	2.8	533	14.8	1%	46%	24%	30%
briar94	724	$148,460	$217,677	7971	2211	445	3.0	455	4.6	38%	69%	11%	20%

District	# Obs	Mean Nom Price	Mean Real Price	Mean Lot Size	Mean Fin Sqft	Mean Unfin Sqft	Mean Baths	Mean Garage	Mean Age	% New	% Two Story	% Ranch	% Other Style
briar95	686	$153,122	$210,594	7723	2190	457	2.9	457	5.2	32%	70%	10%	20%
briar96	670	$162,678	$211,356	8086	2185	524	2.9	466	5.3	35%	69%	10%	21%
briar97	616	$168,663	$210,986	8135	2244	455	2.9	472	5.5	36%	67%	14%	19%
briar98	879	$176,154	$209,331	8047	2168	575	2.9	478	5.1	40%	66%	16%	18%
briar99	715	$184,283	$206,590	8104	2196	542	2.9	478	6.7	14%	68%	15%	17%
nor94	88	$134,726	$197,539	7159	1895	441	2.6	435	5.2	32%	65%	9%	26%
nor95	133	$147,592	$202,990	8241	2005	602	2.7	463	4.3	38%	69%	12%	19%
nor96	129	$147,144	$191,174	7920	1970	578	2.6	462	5.8	10%	71%	9%	20%
nor97	62	$139,971	$175,094	7497	1759	290	2.4	426	9.3	0%	58%	16%	26%
nor98	74	$154,143	$183,175	7579	1864	507	2.5	453	9.7	0%	49%	9%	42%
nor99	53	$157,681	$176,767	7349	1790	433	2.5	441	10.0	0%	58%	15%	27%
per94	44	$312,112	$457,628	18315	3874	732	3.8	659	2.0	52%	89%	11%	0%
per95	70	$317,746	$437,009	20675	3781	756	3.7	687	2.4	34%	90%	10%	0%
per96	91	$299,344	$388,916	18383	3489	879	3.5	659	2.4	43%	85%	15%	0%
per97	100	$311,534	$389,708	16748	3568	893	3.7	670	2.3	50%	82%	18%	0%
per98	150	$320,807	$381,230	18852	3468	869	3.5	637	2.5	49%	61%	38%	1%
per99	94	$366,951	$411,368	20014	3734	827	3.7	666	4.2	26%	79%	21%	0%